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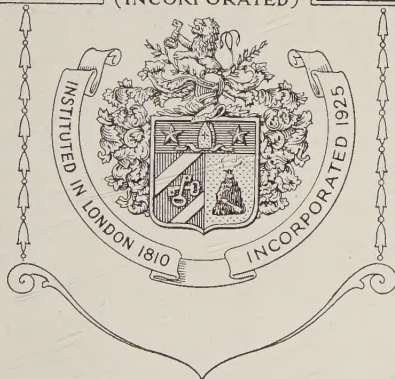


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THE [MINOR] PRINCIPIA

THE [MINOR] PRINCIPIA

OR

THE FIRST PRINCIPLES OF NATURAL THINGS
DEDUCED

FROM

EXPERIMENTS AND GEOMETRY

OR

A POSTERIORI AND A PRIORI

A POSTHUMOUS TREATISE BY

EMANUEL SWEDENBORG

TRANSLATED FROM THE LATIN BY
ISAIAH TANSLEY, B.A.



SWEDENBORG SOCIETY, BRITISH AND FOREIGN

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PREFACE.

THE *Minor Principia* was left in MS. by Swedenborg. It forms Codex 87 of the author's MSS. preserved in the Royal Academy of Sciences, Stockholm, and covers pages 101 to 444 in vol. ii. of the photolithograph reproduction of the Swedenborg MSS., for which the late R. L. Tafel, Ph.D., was responsible. There are 174 chapters or numbered paragraphs; the writing is in a flowing hand and easy to read, and the diagrams are drawn on the margin or embodied in the text. The title *Minor Principia* given to this work was not used by Swedenborg; but it has been adopted to distinguish it from *The Principia* itself.

Dr Tafel in his *Documents concerning Swedenborg* gives the date of this work as 1720, which the Rev. James Hyde in the *Bibliography of Swedenborg* adopts; but Mr A. H. Stroh, M.A., in his *Abridged Chronological List of the Works of Swedenborg* assigns the year 1728 as the date. As there appears to be no very definite evidence on the point either way, it is sufficient for the purpose to know that the *Minor Principia* was the precursor of the larger work, entitled *The Principia*, which Swedenborg published as vol. i. of his *magnum opus* entitled *Opera Philosophica et Mineralia*. In his earlier work he seems to have made an experimental attempt to deal with certain abstruse questions which were finally developed and embodied in *The Principia* itself. In the *Minor Principia* we find him dealing with particles which run out into the tenth order, while in his published work he treats of finites, actives, and elements.

In this preliminary essay he goes into very minute detail in his discussion of the origin of points, their integration, and relation to motion. We also find here indications of those cosmological speculations which were to take ultimate form in *The Principia*. If we were writing an Introduction to the

present work we should direct the reader's attention to some of the remarkable and suggestive ideas to be found therein; it must suffice, however, to refer to his theory of undulatory pressure, which is one of the sequents of his theory of motion.

Undulatory pressure is now regarded as associated with the phenomenon of light. In order to put the reader in possession of the facts which show the relation of Swedenborg's ideas to modern theories, we venture to quote from our Introduction to *The Principia* :—

“It is now established that light exerts pressure; by means of such pressure the sun drives minute particles even out of his system. Dr Poynting deals with this subject in his little work entitled *The Pressure of Light*. He tells us that light can be shown by experiment to exert pressure. ‘It is just a hundred years,’ he says, ‘since Thomas Young killed the corpuscular theory of light and founded in its place the theory that light consists of waves, but there was no reason at that time to suppose that the waves could press, and so experiments to detect light-pressure ceased for nearly a century.’¹ In 1873 Clerk Maxwell enunciated his electro-magnetic theory of light, a theory now universally accepted. His calculations on the subject showed that strong sunlight falling perpendicularly against a black surface exerts a pressure of about the two-hundred-thousandth of a grain on a square inch. Now light is produced by waves or undulations, and we might call the pressure resulting therefrom undulatory pressure. Dr Poynting says, ‘It is interesting to know that whatever kind of waves we imagine, so long as they have the properties which we observe in light, these waves must press against the surface from which they start, and they must press against the surface on which they strike. They must, in fact, carry momentum with them just as surely as if they were moving particles on the old corpuscular theory. The fundamental idea of the proof is, that a train of waves is somewhat like a compressed spiral spring. The waves contain energy.’²

¹ P. 15.

² Dr Poynting, F.R.S., *The Pressure of Light*, p. 21.

“Singularly enough, words almost similar to the above were written by Swedenborg one hundred years ago. ‘Undulatory pressure,’ he says, ‘is the cause of sight, light, and colour. It extends from the sun to the earth. There is in light nothing which cannot be explained by the rules and mechanism of undulatory pressure.’¹ With slight reservations, these words are so remarkable that they might almost be supposed to be a quotation from a modern text-book on science, and particularly since their author believed that there is an all-pervading medium or ether. As a matter of fact it is pretty well established that pressure does extend from the sun to the earth, and that by means of radiant pressure that body ‘drives the finest particles altogether away from his system.’² Let us then quote again from Swedenborg: ‘That an undulation from the sun,’ he says, ‘and pressure from the same can be maintained throughout so great a distance as to our earth arises from the perfectly regular arrangement and connection of the particles.’³ This inference Swedenborg drew from his *a priori* principles, for there were no means of experimentally proving it in his day. It was not a guess but a true inference from the theory on which he was working in the earlier treatise. The electronic theory of matter which has displaced the old solid atom idea, and to which the views of Swedenborg so nearly approximate, as we have shown above, fully substantiates the conception of radiant pressure. Professor Arrhenius refers to the question of radiant pressure in his book the *Life of the Universe*. He refers therein to Maxwell’s wonderful prediction of the amount of radiant pressure, and he states that it was he himself who showed in 1900 the importance of this new universal force. Further, the explanation of the Aurora Borealis is now based on the phenomena produced by radiant pressure. Electrons emitted by the sun, as the result of the light-pressure exceeding the attraction of gravitation exercised on such minute

¹ *The Minor Principia*, no. 130.
The Minor Principia, no. 129.

² *The Pressure of Light*, p. 82.

particles, are driven through the space of ninety-three millions of miles into our atmosphere. When these minute bodies enter the earth's magnetic field, they follow the lines of force in spirals towards the poles. On their way certain gases are electrified, causing them to phosphoresce, and thus give rise to this wonderful northern phenomenon."

The above subject when followed out in detail in those sections of the book which deal with it, together with other matters treated of, show how eagerly Swedenborg was endeavouring to find an explanation of the universe and its origin. The *Minor Principia* undoubtedly deserves a place in the history of thought; and although Swedenborg himself allowed it to remain in MS. it is only just to his memory to place it within the reach of the student.

I have gratefully to acknowledge the minute care with which the proofs have been read by my friend Mr J. R. Rendell, B.A., my co-worker in the translation of *The Principia*.

ISAIAH TANSLEY.

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THE [MINOR] PRINCIPIA.

1. A PHILOSOPHICAL THEORY CONCERNING THE ORIGIN OF NATURAL THINGS.

For a long time it has been a subject of discussion with the learned whether natural philosophy, throughout its whole extent, is based on the same fundamental principles as geometry, that is, whether nature as given to us by the Supreme Will is simply geometrical, or, to use a freer term, is entirely mechanical, or whether all the operations, phenomena, and elements of nature proceed by a kind of mechanism, and like that which we have long known and been familiar with through geometry. Some take a negative view of this, but others assent to it, because almost all the constituent parts of figures, masses, stable bodies and forms are invisible, and have not yet been revealed by experiment and rational investigation; consequently they consider that some of the philosophers of our country take refuge in the same ideas as the ancients, preferring to resort for an explanation to occult qualities, and to conceal their ignorance under fallacious conceptions rather than to bring that to the light which they foresee will be disproved by the learned of a subsequent age. But others maintain, and try to prove, that nature is wholly and entirely mechanical, and that everything that takes place among invisible particles proceeds geometrically, acknowledging that the only difference is that which exists between greater and less. For they think that nature acts in the same way in the least things as she does in the greatest; and they rest satisfied to prove this by examples; seeing, as they do, the same characteristic of analogy and law when they deal with vast quantities as when dealing with infinitely small ones. For these reasons they desire that nothing in nature should be

considered occult, except where phenomena have not yet come to our knowledge through the understanding and experiment.

Since, therefore, in things of a larger kind, and apprehensible by our senses, nothing has hitherto been found to exist that does not acknowledge geometrical rules, and as all nature is visible, I consequently know not whether it is permissible to take refuge in something of an occult nature, and in a quality other than that which is based on exact philosophical principles. I also know not whether the human mind can rest in, and, in a way, acknowledge a theory which is based upon a mechanism either different from, or ampler than that which has long been made known. In order that the truth may be more evident, I desire to deal with those first principles which have been set forth both by experiment and geometry, that is, a posteriori and a priori. I, therefore, fully hope that it will be seen, whether the mind ought to be content with occult qualities, or with those that are placed, as it were, in the light of geometry. Those who desire to search out the matter will find that natural philosophy and geometry have the same origin. If, according to our thesis, it is true that there is nothing in nature that is not geometrical, then the origin of nature and geometry must be acknowledged to be the same.

In geometry the mathematical point is the primary entity. From this arises the line, as a result either of an infinite series of points, or of their motion; then from this stream an area is derived, and from this again a solid body is said to originate. And thus geometry takes its rise from a formless and imponderable point as if from something unknown. Geometry can describe the nature of the point only obscurely by means of words. It cannot be said at all to have substantiality, since it gives birth to the line, the area, and by manifold motion, a solid. But it is regarded as unknowable, and non-conceptual, in order that something capable of being known may be arrived at, as in the case with respect to differences in the calculus of infinities. Geometry, however, is not in fault, since the primary entity is hardly capable of being defined except by bare words; it cannot be visualized.

If we wish to think of the nature of the world before its existence or creation, when as yet there was no matter, nor even the point, by whose movement or flow, the line or the solid could arise, then we must conceive it as being absolutely empty, or that in the place of the world there was a kind of immense void in which there was nothing whatever that would seem capable of giving rise to matter. At that time such a point flowing of itself or from another, or anything finite, could scarcely be conceived. Consequently our philosophy or reasoning concerning the beginning of things ought to go still further back, and consider whether in that absolute void something may not be comprehended that could give origin or birth to some entity from which the line, the surface and the solid might be produced.

If a kind of void be granted in which nothing existed that could move in a material and geometrical sense, much less produce anything, then it must be entirely infinite, and have existed before geometry; this was primitive nature which obeyed no geometrical laws, such as they are known to us. Geometry had not yet been conceived or born, since the point which could flow or move mechanically did not exist in nature. In this state even our mind is blind; there is nothing here except what is infinite and surpasses our comprehension. Nor does the matter seem capable of being expressed in any other way than this, that the beginning of regular and geometrical nature was an immense void, and that the primary origin was only infinite motion in an infinitely small space. But in using such an expression we seem to trifle with words, since we cannot form a conception of infinite motion, apart from something moving or moved, nor of such motion in an infinitely small space where there is no space, in which case two infinities may here be supposed—in motion, the infinite of velocity, and in place, the infinite of smallness. But because such infinity cannot be apprehended geometrically, we must consequently have recourse altogether to something of an infinite kind, and of a self-originating nature, or a Supreme God and prime mover must be acknowledged, who is without any geometrical attribute or

quality, who alone is greatest and least infinite motion, and who by His own infinite motion in an infinitely small space gives rise to the point from which geometry has its commencement and origin, and according to whose rules the whole of nature then acts.

We, therefore, carry our reasoning through these infinities up to a certain primarily existing entity or point. For we can only define this point as having originated from infinite motion in an infinitely small space; consequently from such infinity something definite existed, that is, the first natural point, from which all other things derive their origin; and, together with this very point, geometry, or nature bounded by geometrical laws, was born. This point seems to be something between the infinite and the finite. It participates both of infinite nature, which has no geometrical rules such as our world has, and also of geometrical nature. By means of this point one is permitted to enter, as it were, through the door into the presence of that nature which appeals to and is adapted to our senses. That from something infinite the finite can arise is proved by the infinitesimal calculus; and geometry also acknowledges the fact, that from the motion or infinite fluxion of points something of a finite character is determined, whether it be the line or something else. The science of physics also which regards matter as infinitely divisible proves the same.

2. THE INFINITE AS WELL AS THE FINITE MOTION OF THE FIRST NATURAL POINT GENERATES THE LINE, THE SURFACE, AND THE SOLID.

We assume this natural point to be almost the same as the mathematical point. This is the beginning or primary entity of lines, consequently of figures, and thus of the whole of geometry. It is the primary entity of the lines that exist in nature, and, consequently, of solid bodies, and of the whole of nature. This is defined as non-infinite or as partaking of both. But how this was able to generate the finite has been stated in the preceding paragraph. It is not for us to determine how, from infinite things, something finite can be produced; but since nature, or

that nature which follows natural and geometrical laws, begins here, therefore a beginning must be made with this point—which is defined by some part of itself—and not from that which is purely infinite.

Since motion alone seems to have produced this point, therefore no other figure can be ascribed to it than that which agrees with, and is most adapted to motion; and this figure is the spherical one, of which we shall treat further in the following pages. Consequently, the figure must be like the motion which produces the spherical form.

Now, let this natural point be of any figure whatever, it is sufficient that it is something finite, and limited, as it were, by motion, or by its primary source.¹ Let it then be assumed that such a point moves with very great velocity along a certain line, that is from one end of the line to the other, and that this motion returns upon itself, so that if in

Fig 1.

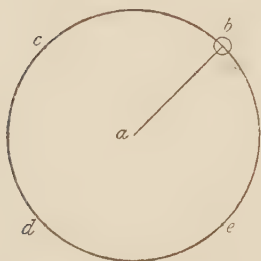
fig. 1 the point in *a* is carried with very great velocity from *a* to *b*, and back *a*  again from *b* to *a*, and in this way

continuously throughout the same line back and forth; then if the velocity is very great, or if, first, we suppose the velocity to be infinite, then at no moment is there an interruption in the movement of the point, and since there is no break, but the movement due to the infinite velocity is continuous from one end to the other, a line is formed, just as if an infinite series of points constituted such a line. The idea involved in this supposition can be made clearer by an example. If a ball of lead or of some other substance be rotated round a definite axis or centre with very great velocity, a continuous surface, as it were, is formed. Thus, in fig. 2, if the ball *b* be very rapidly revolved in the circumference *bedc* by the radius *ab*, and if the velocity be very great, then to all intents and purposes a surface hard and unyielding is formed in every place by the body *b*, since at no moment is there a visible break when *b* is in motion,

¹ From the margin of the MS. Let the point be finite and the motion infinite.

but, according to our conception, it is in every point of the surface at the same instant. If the moving force were hidden from our sight, that is, if the means of movement were invisible,

Fig. 2.



and only the moving ball seen, and if the circular movement were very rapid, the mind would be able to perceive nothing but a continuous, and, as it were, quiescent surface; for in no place would the ball be seen to delay or rest in any point, but to be present throughout the entire surface. This becomes clearly evident when a wheel with one or several teeth is caused to rotate, some-

thing continuous and not divided into teeth is then seen. Still more would it be believed to be a continuous and perpetual circle if the motion were that of infinite velocity, or approaching proximately to infinity. Then there would be nothing that did not prove continuity; the ball would be at *c* and *d* in the same instant that it was at *b*, and so throughout the entire circle. Consequently, by the extremely rapid movement of a single finite point, whether along a line or throughout a circle, either a straight line or a circle might be formed, just as if an indefinite number of points were able, without motion, to form the same line by being joined together in a series. The truth of our proposition consequently is clear, that is, that the natural or infinite, as also the finite motion of a first point, can produce a line; this takes place as well visibly as invisibly.

In the same way a surface, either linear or circular, can be formed, that is, by the help of a very rapid movement. If in fig. 3 this point moves from *m* to

Fig. 3.

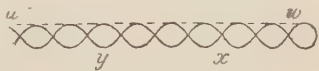
s, but on the way takes a downward and an upward direction, so as to proceed from *m* to *n*, then upward



to *o*, and so on, until it comes to the end *s*, returning back again by the same way to *m*, then I maintain that this same simple point is able to trace out a kind of plane

surface. In order to put the matter more clearly, let the motion of this point be an upward and downward one, or let it be undulatory, as it were, during the path which it traverses from m to s ; and let the undulation be very small, with no break recognisable, and let the motion be one of infinite velocity, then the plane which the point has traced out by its movement must be considered as formed of continuous and connected points. By reason of the velocity no break can be conceived, but in every place the point makes itself felt and is apparent, since the interval of time between its presence in two different places is so small as to be imperceptible. In the same way, if the undulation is still greater, or a kind of wave motion as in fig. 4, so that the point is carried with very great velocity from u to w by the undulation or wave motion, shown in the

Fig. 4.



figure, and let it return in the reverse direction by a similar undulation, but not along the same path, then again a kind of plane surface is formed by the extremely rapid movement of a single point, which I desired to show for the sake of demonstration; not that I hold that the point is carried along by this motion.

So, too, a circular plane can be formed in the same way, and traced out by a single point actuated by a very rapid motion.

Fig. 5.

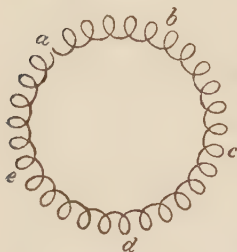


As for example, if in fig. 5 the point flows from a to b and e , and thus to its place of origin with either a tremulatory or undulatory motion, nevertheless in such a way that the continuous undulation does not proceed along the same path, consequently—just as was noticed in regard to the surface or lineal area—a portion of a surface, or a part of a

circular area is formed; or, if in fig. 6 the point flows in a circular manner, and thus completes the whole larger circle $abcde$ by a circular motion. And if the point is so deflected,

and so proceeds throughout the entire periphery, that this circular rotation does not continually return to the same places, but is always changing, and if then the motion is very

Fig. 6.

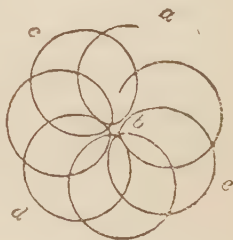


rapid, part of a circular area, or a kind of denser surface is formed; because, as previously stated, no perceptible break intervenes in its passing from one part to another; and since no other idea can be formed than that the point is continuously in every part, and that, provided the velocity of the point is sufficiently great, there is an unbroken

series of points.

In the same way an entire circular area may also be formed. Consider fig. 7. If the point flows from *a* to *b*, or to the centre and so throughout the circle to the periphery in *c*, and back again to the periphery, and so on continuously by means of a kind of circular flow from centre to periphery, until it has completed the entire greater periphery; if again by similar circles but not the same path, the point completes a greater circle, then if the velocity of its flow be very great, and no perceptible interval intervenes between one part of the circle and another, but it is found within any inappreciable interval in any place in the area, then, it can be affirmed on the same basis, that the point is in every part, and that a circular area is formed by means of a single point endowed with very great velocity.

Fig. 7.



But before we proceed further, let us see whether in the nature of things such a velocity is possible that a circle and an area may be formed from a moving point. First, we must consider that the motion exists in a place where there is no resistance, and where it can increase to infinity. At another time I should prefer to state this instead of using an example, although an example would rather illustrate than prove it. It is

an undoubted fact that our earth moves about its axis, and that every twenty-four hours it rotates once round its centre or centre line. If then we consider some point, or a tiny particle of dust at the equator, where the circle is greatest, then that point, although at rest, is nevertheless carried round with the revolution of the earth, and within twenty-four hours has completed 5400 German miles, or 64,800,000 Swedish ells, or, in every second, 750 such ells. Let it be supposed that the point is impelled with the same velocity round a circle with which the said dust-particle is moved at the equator; and suppose, also, that the circumference of this circle which the point describes is equal only to the thousandth part of a line in that ell, then this point, if carried along in a second of time with the same velocity as that of the dust-particle, would move round the circumference of such a circle 1,800,000,000 times. And in this case, the point must be considered to be in every part of the circle, or in every part of the surface or area in such a way that the circular area, according to our understanding of it, is able to be traced out by means of motion and flow alone. But these things have been adduced merely for the purpose of illustration, not as a proof; especially since the small particle with the circular motion is at rest, and this point describes an infinitely smaller circle or circumference than that which has been taken as an example.

We have now laboured sufficiently to show that a line or surface can be formed by the motion of a point, consequently, it is not difficult to prove that a solid can be produced [by the same means]. If the point by its motion forms not only the entire surface of a circle, but, in the very formation of the surface, describes infinitely small circles, or forms very minute surfaces, in such a way that the entire surface consists of an infinite number of circles described during the process, then also a sphere results which may be designated a solid. For in this case the point is carried along, not only in the direction of a line, but also laterally throughout a surface; and by means of circles formed during the process, or continuous circumvolution, a real solid is duly formed. But

this cannot be easily made clear to the eye, until those things that follow are seen; for we shall afterwards deal fully with the movement of the point to a complete result, and with the formation of a spherical particle by means of such movement.

3. THE MOTION OF THE NATURAL POINT PROCEEDS BY MEANS OF CIRCLES.

Here we must consider the character of the motion, whether it proceeds along a right line or throughout a circle. We must conceive that this motion takes place in an empty space or vacuum, where there can be no strain from one place to another; no force which either tends toward or from the centre. When the motion is in a definite element, as for example in our atmosphere, then it takes the direction of a right line, so that if a body falls of itself from a height it tends to the centre, and, at least to our eyes, falls perpendicularly in a right line, since there is a certain force which directs the body as it falls along that line. Equally so if it is thrown upward along the same path, or the same perpendicular. So, too, if it were propelled horizontally, and there were no tendency toward the centre, it would be carried horizontally, or parallel to the horizon without deflection. The reason is, that this takes place in an elementary sphere, where the question of place to place is involved, where vertical and horizontal lines have to be considered, and where the impulse or the linear movements are under the direction of a centripetal force. But here another consideration comes in, since there is nowhere up or down, horizon, quarter, or direction of place to place, but a kind of void, in which there can be no consideration of a centre in respect to other particles, or in respect to anything material. In such a condition of the world a right line cannot be conceived, that is, a line which stretches from one point to another, and gives rise to intermediate distance. Distance cannot be conceived, since place cannot be conceived. As, therefore, there is nowhere either up or down, left or right, but things must be conceived in reference to a single motion,

therefore that motion includes everything which is elsewhere considered in regard to place or impulse.

Let there be motion, therefore, under such conditions; then it cannot be conceived otherwise than as operating everywhere, and embracing all those points which come under the name of quarters; as being in direction both upward and downward, left and right, and as proceeding everywhere in its own sphere. Consequently, that motion must be conceived as circular, which nowhere has a limit, and nowhere a determinate place; nor has it any relation to those things which come to our conception in the vortex and sphere through elementary centripetal particles. I confess that these things are somewhat obscure, and that it is very difficult to form a conception of motion in a circle and of motion from place to place along a line in a vacuum, where place cannot be conceived. An explanation cannot be sought from geometry, since geometry can here determine and indicate nothing, as there is no matter involved, which geometry has for its sole basis. Nevertheless, since geometry cannot explain how a finite point can describe a line, and measure out a definite space, when nothing can be conceived as tending hither or thither, we must have recourse wholly to a motion that has nothing in common with motion in an elementary state, but which includes every kind of motion, that is to say, we must come to circular motion.

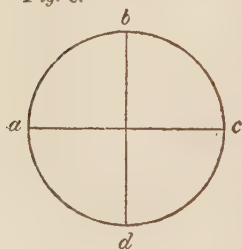
As to the origin of motion and the primary impulse, the occasion for explaining these has not arisen. We shall deal with this later, in paragraph 23, which please connect with the present one.

4. THE MOTION OF THE NATURAL POINT PROCEEDS BY A CIRCULAR SPIRAL, THAT IS, BY A SPIRAL LINE, WHENCE ARISES FIGURE, OR THE PRIMARY PARTICLE.

In the preceding paragraph it has been stated that a point moving in a vacuum cannot be impelled and driven along a right line, because nowhere could a line come under consideration as taking a reclinear path; but the motion runs entirely into the

circular form, that is to say, into that line or figure that has none of those directions that elementary nature affords. From similar reasoning it follows that the point in motion cannot be impelled simply into a circle; for if this were the case, it would immediately take its direction into one quarter. A circle tends to one quarter by virtue of its diameter. For if the area is considered as plane, this plane would extend from one extremity

Fig. 8.

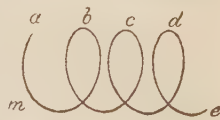


of the diameter to another, and consequently there would be no direction to the remaining parts. As for example, if, in fig. 8, the point were to flow continuously from *a* to *b* through *c* and *d*, and so on uninterruptedly from its place of origin and back again, and thus formed a circle by a continuous movement throughout a circle and formed a circle; and if *a* be

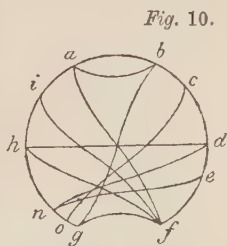
the quarter of origin, or the left hand, *c* the quarter of termination or the right hand, if the moving point always completed this circle from the former quarter to the latter, or from left to right, it follows therefrom, that the motion is linear, as it were, and tends to one quarter, nor does it cause any lateral motion to the south and north, or intermediate points, consequently such circular motion cannot be conceived, when a linear motion cannot be conceived. It follows from this reasoning that the point moving in this vacuum tends to all points, and by its own motion forms not a circle, but a complete surface, that is to say, it is carried equally to all points, or in all directions, and thus marks out a surface by its own motion.

But since such motion throughout a circle is difficult to conceive, it consequently can be represented only by a circular spiral; not indeed by such a spiral as tends in a longitudinal direction, as in fig. 9, from *a* to *b*, *c*, *d* and *e*, since it would then be immediately in the direction from *a* to *d*, or from *m* to *e*, and then by its own motion it would describe a definite right line; but

Fig. 9.



such a spiral as would be continued throughout a definite sphere, and which, by its movement, would form a surface, or which would mark out and touch all the points of a surface; as in fig. 10, if the point is carried from *b* to *g*, from *c* to *o*, from *a* to *f*, and so on throughout, in such a way as to form a definite spiral in the surface itself, that is, that at every instant it is deflected from a circular right line to the right or the left, and for that reason takes a spiral course throughout the same spherical surface. This motion can be better conceived by the imagination, than from



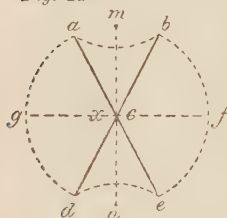
a figure Now conceive a spiral motion, but which tends in no direction outside the surface, but which remains always in the same figure or surface of the sphere, in such a way that the spiral twist takes place in the spherical surface, but not in any part outside the said surface; if, then, a spiral circulation of the point be conceived throughout the sphere or surface of the sphere, but not outside the same, it thence follows that the point by its own flow does not proceed in one direction rather than another; but it flows in such a way, that it is carried in all directions at the same time, and, consequently, by its flow marks out a sphere or the surface of a sphere.

5. WHEN THE NATURAL POINT MOVES IN A SPIRAL MANNER OVER THE SPHERE, THERE IS A SPACE AROUND THE POLES WHERE THIS POINT DOES NOT COME.

Suppose now that the spiral movement of the point over the sphere is according to the mode which has been stated, that is to say, that in its movement it is always being deflected from one point to another, also to another circle of the same sphere, and in this way forms a spiral, it follows from this, that it can come only within a certain distance of the poles. For example, in fig. 11, if one pole is at *m*, and another at *n*, then from the spiral motion of the point moving from *d* towards *b*, or from *e* towards *a*, it can never approach nearer to the pole *m*, than is

indicated by the distances mb or ma , that is to say, its distance from the poles. This distance is formed along the first direction. The spiral movement over the surface of the sphere causes the

Fig. 11.



point to be borne in the same way along the equatorial line, just as takes place in the sphere; consequently, when it reaches the highest point either b , e , a or d , it is deflected back again, and, consequently, describes a kind of circle round the poles, this circle being formed of pure circles, which pass through the point of contact

of that circle; nor does it approach nearer to the poles m and n , or depart farther from them. Therefore, it follows that the locus amb and dne in the sphere is never touched by the moving point, and, consequently, the surface of the sphere is lacking here, the surface being broken, as it were, in that section. Elsewhere the surface is continuous, resulting from the extreme velocity of the moving point, but in these places, or in these loci ab and de , it is broken, there being a gap, as it were, and the circle is incomplete, because the point is never able to enter this section of the sphere. The reason is, as previously stated, that the spiral tendency of the point, always preserving the same distance, is in a lateral direction in its rapid progress round the surface.

For the sake of example, let the point move from c or m . But, since its motion is spiral, when it has described its circle, it does not return to c , but has moved from c towards x . Let the distance cc be twenty degrees, that is, when the point passing through c , having described a spiral circle, returns to the same line, it has been carried from c to x , then it follows, that when it reaches the highest point, or, when a fourth part of a circle has been described, it will have been carried as far as the fourth part of the same, that is to say, as far as $\frac{20^\circ}{4} = 5^\circ$. It follows, then, that this point does not approach nearer the pole m than the distance of five degrees. But, when it has returned to the line gf , it will have been carried from c towards x , to a

distance of twenty degrees. In the same way if it moves from x to m , it will be carried through the spiral traced out from m to a distance of five degrees; so also in de , consequently there is also a fourth part of the degrees round the poles as there is around the equator of the same sphere. The reason is evident; for when it crosses the equator, it always strives towards a pole, and has a tendency to reach it, unless the direction is lateral along the equator, that is to say, spiral.

Or, if the distance mb is twenty-three and a half degrees then the movement of the point in the equator fg , in any circuit whatever, would be ninety-four degrees, whence the distance of the circle ahb is greater from the pole, and this section ahb is clearly a gap, there being no flow of the point there, and consequently no surface.

It is, consequently, evident that, by the aid of the movement of the point throughout the spiral round the sphere, two poles are formed, and that there is another motion of the points around the poles, which forms the section of the same sphere or surface. The circle of this section is touched only by the movement of the point; for the point cannot come within this circle.

6. THIS MOVEMENT OF THE NATURAL POINT MAY ALSO BRING AN EQUATOR INTO CONSIDERATION.

Since there are two poles, and a space like a vacuum around the poles, there is consequently also a line or intermediate circle, which must be called the equator. For if all the lines be cut in the centre, that is, if all those lines—which are spiral—are bisected, an equatorial circle would result from that bisection.

7. THE LINE WHICH CUTS ALL THOSE SPIRAL LINES AT RIGHT ANGLES, FORMS A KIND OF ECLIPTIC, AND THIS ECLIPTIC HAS A DEFINITE OR FIXED NODE OR INTERSECTING POINT WITH THE EQUATOR.

When, then, the point moves spirally, in the way which we have just laid down, not only is there a kind of similarity to poles produced, but a line midway between the poles which in the largest circles is called by the general term, equator; and in the smallest

circles it may retain the same name or designation on account of the similitude, or rather identity, of the subject. But as to the ecliptic, it also is formed by the spiral movement of the point, that is, it is a circle which has a different centre and different poles from those of the equator. The pole of the ecliptic is in that circle which is formed round the poles in the circle of the section which surrounds the poles, which has been shown to be vacant.

Let that spiral be considered which cuts the equator obliquely ; the obliquity of the section is not everywhere the same, but in one part it tends to the right, in another to the left. But if all these things were described, and illustrated by figures and drawings, it would involve much labour, and even then the idea would hardly become clearer to the reader. It is not difficult for any writer to set out diagrams of such things so as to form circles with mutually intersecting lines, and by various calculations to determine the angles, and prove everything geometrically. But such demonstrations are frequently published by those who are content to make easy things difficult, to turn light into darkness, and tie up everything into riddles and knots, believing that the learned world will venerate the teaching on that account, and will, in consequence, exalt the ability of the authors above that of others ; when, nevertheless, it would be very easy to eliminate all those obscurities and difficult points, and by the bare help of a few pages to place before the eyes of the reader all those things with which they had laboured to fill volumes.

As to these spiral lines and tendencies it would also be easy to explain the obliquity of the circles, and the very varied sections in regard to other circles, so as to make it a laborious task for the reader to unravel everything. Hence, as the end is only to treat these things in a plain and simple manner, and the more so, since of themselves they are not easy to understand, our only object is to put the reader into such a position that the ideas and the very truth itself may stand clearly before him.

Take, then, a sphere made of wax or wood, and describe thereon the equator and the circle about the poles, and spiral circles from the extremity of the section throughout the equator to the other

extremity of the opposite section, and thus throughout the complete spiral; and let the lines be so traced as make them quite visible. Such a mechanical tracing out of the circles will make plain to the eye the whole movement of the natural point about the sphere, and will make conspicuous how obliquely the equator is cut in some parts, how in others the section is less oblique, and how the obliquity is changed in another part of the sphere, and at length, if it is carried farther, how there is an alteration, and how they cut this equator differently

If these spiral circles are cut at right angles, and indeed, in the middle, that is to say, if a circle is described through all those spiral circles, which cuts the former at right angles, the question of an ecliptic will at once arise, and by the same process it will be seen that there will be a definite pole of the ecliptic, which pole, by the uninterrupted movement of such spirals, proceeds, and is also transferred throughout its own circle. This can be experimentally proved. If the same spiral be traced again and again on the wooden sphere, or if the delineation or tracing be carried uninterruptedly round that sphere, then another situation of the spirals will be seen to arise, and the equator will be found to be cut in a different way. Consequently, the pole will not remain in the same part of the ecliptic, but will advance gradually along the circle.

For the same reason it follows that this ecliptic circle does not cut the equator always in the same place, but that the section gradually moves across it, which simply means that the nodes are changed. If the place is changed, either the pole of the ecliptic is differently transferred, and, therefore, the node also moved, or the junction of the ecliptic with the equator is moved.

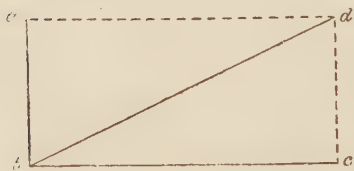
8. THE PASSAGE OF THE POINT ALONG THE ECLIPTIC TAKES PLACE AT EQUAL DISTANCES, BUT THOSE DISTANCES MAY BE GREATER OR LESS ACCORDING TO THE VELOCITY OF THE MOTION.

As to the first consideration, the passage of the moving point along its ecliptic, it can be seen at once that it takes place

uniformly, that is, by distances that are always the same. For if the spiral is regular, then the point moves along that circle uniformly, but along the equator variably. In this movement there cannot possibly be any irregularity; for there is nothing to retard or accelerate the motion, there is nowhere any upward or downward, and consequently no retardation or increase of motion; therefore, the movement of the point toward the ecliptic cannot but be regular. Whence in the greater circle the ecliptic is divided into three hundred and sixty equal degrees, which our earth or planet describes daily, or in equal times, in such a way that it passes through one degree each day. If we consider the nature of this spiral, we shall see that it returns to its own intermediate line or ecliptic with every revolution, but that the point has been transferred further, which forward movement takes place in equal times or at every revolution.

If this spiral movement arises from the compounding of two motions round the same circumference, and the movement is equal all round, it is also equal on both sides. That circle which cuts perpendicularly any circle whatever will be everywhere distinguished by an equal section and transference, just

Fig. 12.



as if, in fig. 12, a motion from *a* to *b*, and from *b* to *c*, were uniform, but the time occupied were the same; then the same body would move with greater velocity from *b* to *c* than *a* to *b*. If a body were impelled at these

two rates, then, in the same time, it would be carried with uniform velocity from *b* to *d*. The reason of this is, that as the body is under the influence of two uniform velocities, the resultant velocity is uniform, just as is the case with circles.

But if the first or vertical motion which completes the circuit is not so great, then a longer time will be required before it returns to its ecliptic, and consequently a greater velocity of translation or progression is possible in the ecliptic; therefore from the

velocity of the motion of the point there will be a greater or less translation along the ecliptic. Still, we must candidly confess that it is by no means easy to find out what is the difference between the motion or translation of the point round the circuit and its progress along the ecliptic. For it is possible that in three hundred and sixty revolutions it passes along the ecliptic once, and it may also accomplish this in no more than ten or fifteen. This results from the primary impulse of the motion. Still, I do not doubt that the reason and a clear explanation may also be brought to light.

In the larger circle we see that there are three hundred and sixty revolutions possible before the ecliptic has been once described ; in the case of the planets more or less distant, more or fewer revolutions are possible before they have traversed the ecliptic once. But we must treat of these subjects elsewhere ; and as a full explanation would be necessary and considerable labour required, it is sufficient to indicate the nature of the motion. For being still on the threshold of the subject, it is not yet the time to pass to more interior matters.

That the primary motion of the point follows the course of the spiral in the sphere I propose to demonstrate more clearly in the following pages ; here it is sufficient merely to indicate that the motion of the greater circles necessarily arises from the nature of the smaller ones. Motion in the least circles rules and governs, as it were, motion in the greatest circles. In the greatest, it is perfectly clear that the motion is along the equator, that it is along the ecliptic, that there are two opposite poles, that there are poles of the ecliptic which are distant from the terrestrial poles twenty-three and a half degrees, that a body is carried along the ecliptic uniformly through distances that are called degrees. Now, since our philosophers see the progression of the nodes, or the points of intersection of the ecliptic with the equator, to be carried along at the same time, they form the idea of a spiral movement. It is just the same in the smallest things which originate motion in larger bodies. For in the volume the same motion is copied as that which is found in each particle of

the volume. But the truth of this will be more fully seen in the following pages.

9. THIS NATURAL POINT WILL RETURN TO THE SAME PLACE IN THE ECLIPTIC ONLY AFTER AN INFINITE NUMBER OF REVOLUTIONS; AND THIS IS THE REASON WHY A PERSISTENT AND, AS IT WERE, CONTINUOUS SURFACE IS FORMED.

If the point moves along the ecliptic with always equal degrees or distances, it does not thence follow that the distances or degrees are such as to divide up that circle, that is, the ecliptic, equally, and in such a way that the point would return to the same spot after one circuit of the ecliptic. If now, a circle, or the zodiac, were divided into three hundred and sixty degrees, and a point were moved one degree by any revolution, then necessarily it would return to the same spot or to the same place in the zodiac, provided it described that circle once. But it rarely happens in spirals of this kind that a point returns to the same place, or that it so divides the circle by such an always identical and equal translation, as to cause the point to return to the same place. For if there were any break, then the moving point would immediately come into parts of the zodiac other than would be the case if there were no break. And if the break were of such a kind, then the point would never be able to return to the same place in the ecliptic, except after an infinite number of revolutions. It consequently follows that if the division is not equal, or the translation of the moving point through the ecliptic is according to equal divisions, then it will arrive at the same place only after countless revolutions.

If, for example, a circle is unequally graduated, and the divisions are broken up in such a way that at the limit or about the place where the graduation begins, the reckoning does not fall or terminate in the same place, it advances thence to other parts in the same circle, and although it marks out equal distances, yet returns to the same place only after many, and frequently, an infinite number of revolutions. For example, let any motion

whatever take place in a circle, of twenty-three and a half or forty-seven degrees, it will not return to the same place or the same point in the circle in which it began. So also we may suppose it happens here.

If, therefore, the translation or movement of the point along the ecliptic is uniform, yet such that the point returns to the same place only after many revolutions, then necessarily the surface which arises from the flow of the point will appear to be a continuous surface; for at no conceivable moment is the point found exactly in the same place. This is effected by the rate of the motion; and, since there is no perceptible interval of time, the surface clearly appears to be, as it were, continuous, and the point to be perceptible in every part of it. If, then, such a movement be conceived, it must necessarily be conceived always present and everywhere unbroken, just as if the surface consisted of an infinite number of points, and had no break in it.

But if the point were to move along its ecliptic with uniform velocity then a gap might be conceived to exist amongst those degrees or intervals along the distance traversed, but these would vanish if it did not return to the same place, but proximately, and so on continuously throughout the whole ecliptic.

10. THIS FLOW OF THE NATURAL POINT IS CONTINUOUS AND EVERYWHERE EQUAL.

We shall give some little consideration later to the nature of the first impulse or motion of the point. But this impulse having been given, and a beginning having been made in the movement of the point, we say, then, that the motion so imparted to it is continuous, uninterrupted, and without fear of diminution. The space in which the point moves must be regarded as a perfect vacuum, free from any matter whatsoever. In that space there is nothing but the primary motion of the point, whose mechanism we are unable to discuss because it existed before the origin of any mechanism. If, therefore, this motion has been initiated, and it then continues in a vacuum where there is no

resistance, where there is nothing to impede the motion, or to destroy it by action in a contrary direction, the motion will be continuous and entirely uninterrupted. For there are neither centripetal nor centrifugal tendencies, that is to say, there is no force seeking the centre or flying from it, for the point does not move within any circle capable of revolution about a centre, but the very point itself is motion. In an element which consists of particles there is a centripetal and a centrifugal tendency; for this is an elementary quality, and which is the natural result of the particles of the element which flow freely one among another, consequently, since this very point itself is motion, and gives rise to motion among elementary particles, I know not whether that which moves, gives rise to that mechanism, and originates elementary motions, is capable of possessing that quality which it is about to impart. If there is any centripetal tendency, or a falling from a higher to a lower place, or an effort to reach higher parts, from the centre, then one could at once suppose that there would be a definite reason, depending on the cause itself, why the motion should be either increased or lessened; and since this is impossible, there can be no retardation, or anything to increase or diminish the impulse originally imparted.

For this point has nowhere any upward, downward, or lateral direction, place nowhere existing. The point moves in a void, but not in a place, such as it is in some elementary sphere. It does not exercise pressure upon particles, it is not carried above or below any particles, since there are no particles above which it may be said that this point or this surface is able to be carried.

It would seem that nothing could resist this point except another point, which in the same way would make its own sphere, and by its movement form a surface. And suppose one point were to come into collision with another—if such a thing could happen—then the one would be able to move the other. Although this point which we have endeavoured to describe is not material, as we have previously stated, still it would maintain the same motion, although in the vicinity. But these things will be better seen in the following pages.

If now you prefer to say that toward one pole is an upward direction, and toward the opposite pole a downward direction, you are at liberty to do so; in the same way you might say that men in the north are in the higher regions or spheres of the earth, and those in the south in the lower regions. The matter, however, cannot be put in this way, for all who are in the world may be said to live above or below. So also here, we can speak of up and down in regard to the poles, but we cannot suppose that such is really the case; for in the sphere of this motion or activity there is no up or down.

It follows from these things that the movement of the point is continuous, and cannot be disturbed or interfered with, and that it always preserves its own motion the same, that is, that its motion is eternal; unless, in truth, it is stopped by the prime mover, God Himself. Also the magnitude of the sphere remains always the same, is always identical in form and motion, and in respect to all these things has a kind of perennial nature.

11. THIS MOVEMENT OF THE POINT CANNOT BE DESIGNATED
EITHER MOTION OR REST; BUT IT HAS SOMETHING
COMMON TO BOTH.

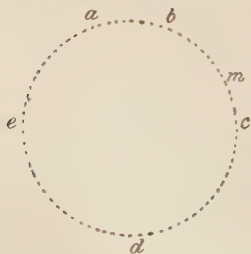
This movement proceeds in a vacuum where there is nothing but primary points driven by a continuous and infinite motion, whence it cannot be said that it is either up or down, consequently there is nowhere any place or space. Since, therefore, the movement proceeds under such circumstances, I do not know whether this should be called motion. Motion has relation to neighbouring bodies, to particles moving about one another, and to the place in which it is moved. Consequently, in this respect it can be scarcely related to such motion as takes place elsewhere in an element. It cannot be said to be either up or down, but the term movement can be used in regard to the definite surface of the sphere which it describes. Hence, although in comparison with the motions which take place in a elemental place, it must be designated motion; still if such motion be abstracted, it would scarcely deserve the name of

motion, whence it has something common to motion and rest. Nor can it be likened to anything else than the motion of the surface of our earth, when each day it moves round from west to east. If the inhabitants of the earth can, in a single minute, be moved a distance of from six to seven hundred ells from west to east; so also round the sun, along the ecliptic; also this moving point can be said to be moved, although in a certain respect it may be considered at rest. The inhabitants are in a state of rest here, although they are borne along with an exceedingly rapid motion. We are at rest in an element, of which Newton and others have most ably treated.

12. A SINGLE POINT CAN OF ITSELF GIVE RISE TO A SURFACE;
SO ALSO SEVERAL POINTS TOGETHER, IF THEY MOVE IN
THE SAME CIRCLE AND IN THE SAME WAY.

How a single point by its continuous and very rapid movement can mark out a definite surface, has been sufficiently stated above already, so that it would be superfluous to add anything further. But if it should happen—whether this can be the case, I wish to explain more fully in the following pages—that several points are moving in the same circle and keep the same path, then they could also give rise to that very surface, and almost in the same way; nor would one point be an impediment to another. The circle and the

Fig. 13.



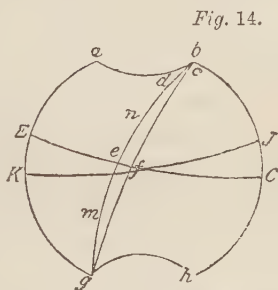
path are described by all the points at the same time. One point follows another; the velocity of one is the same as the velocity of another; consequently none can impinge on another, and much less meet in an opposite direction; but one circle, as it were, and one chain continually describe the same path. If, for example, in fig. 13 a thousand points, or myriads of points, all moving with equal speed, describe the same circle *abcde*, then, since one follows another with equal speed, therefore, when the point *b* comes to

c, the point *a* arrives at *m*, and so on throughout the whole circle; the same is the case with points moving in the remaining order. When a single point moves in a spiral manner, and, therefore, with steady change of position, cuts the ecliptic or any greater or less circle of the sphere, then the rest of the points that follow do the same. It follows, therefore, that if several, or an almost infinite number of points are in one and the same circle, and are borne along in the same path in such a way, that, taken together, they form either a half or a whole circle, then one is no impediment to another, but they are capable of marking out a surface just as if there were only one point; that is, a circle of such points creates the same surface as one point taken by itself.

13. IF SEVERAL POINTS, HOWEVER, MOVE IN ANOTHER CIRCLE OF THE SAME SPHERE, IN SUCH A WAY THAT THEY CROSS THE ECLIPTIC AT THE SAME TIME, BUT NOT THE SAME DEGREE OF THE ECLIPTIC, THEN THEY CAN MEET IN THE POLAR CIRCLE, ESPECIALLY IF ONE POINT IS NEAR ANOTHER.

If two points were to move on the same surface, and each could be referred to the same centre, so that each described separately its own circle in the same surface of the sphere, it must be noted that, according to our supposition, each has the same centre, but that each describes its own circle.

If now, in fig. 14, one point were in *f* and moved from it to the smaller or polar circle at *b*, and the other point were in *n* or *m*, that is, in another circle of the same sphere, then each point would move without interference, and one would not come in contact with the other. For when the point *f* came to *b* or to the smaller circle, then the point *m*, which is in another circle, would not have reached *b*, but only *n*, and thus is at the same



distance from that point as before; nor do they approach so nearly that one in some smaller circle is able to touch, or, as it were, collide with another, but they are always separated by the same length of chord.

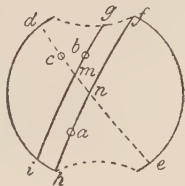
It can be seen from these things, that several, or an infinite number of points, may move in the surface of the same sphere, and, indeed, may be revolving in different circles, and yet never meet or touch, simply on this condition, that the same centre is common to all. But if one point were at f and another at e , so progressing that they cross the larger circle, that is, the ecliptic, at the same moment, the point f being at f , and the point e at e , then if they are following another closely so that they cannot be in the smaller circle at the same time, whether in b or in some greater circle between the polar circle and the ecliptic, one point will certainly touch another and move it from its place. This can be clearly seen, for the space in which they move will be more restricted in the smaller circle b , than it was in the greater circle f and e . In such case the points will come nearer and nearer together until one will push the other aside, or until all experience this and they are forced to change their centres. But, now, suppose each to cross the ecliptic in a similar way, and to cut it at an equal interval; if they are distant from one another so that in a certain smaller circle one is unable to come into contact with another, then each will be able to move uninterruptedly over the same sphere, but not so elsewhere.

14. POINTS HAVING A COMMON CENTRE DO NOT EASILY MEET, BUT THEY FLOW UNINTERRUPTEDLY IN THE SAME SURFACE; AND IF THEY DO NOT COME INTO CONTACT WHEN THEY HAVE DESCRIBED THE FIRST CIRCLE, THEN THEY WILL NEVER MEET.

Because there happens to be a small eccentricity, it can, indeed, rarely happen that several points will have the same centre, and flow over the same surface with many others round the same centre; nevertheless, if a number of points are concentric, or describe a circle which is near, or complete a circle which is

more remote or opposite to it, and if they do not meet in the first revolution, then they will never meet, but they will always be able to flow with the points of the same surface. For example, in fig. 15, let there be three points a , b , c , which separately describe their own circles. Let a describe the circle hf ; b the circle ig ; c the circle de , then, unless they meet at the points of intersection m or n , either from one direction or the other, they will never meet. If any circle cuts another, in any revolution, in two places, that is to say, on both sides of the surface, then all the points are borne along with equal velocity; one does not move more rapidly than another, consequently when the two circles meet, the points are always equally distant from one another, whichever side they come from.

Fig. 15.



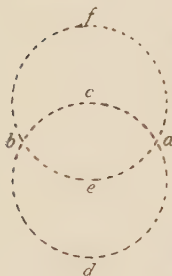
It follows from these things that innumerable points may mark out the same surface, and be carried round one centre, without one coming into contact with another. For if they were to touch one another, they would necessarily be immediately deflected from their path; this cannot take place if they move concordantly.

15. IF ALL THE CIRCLES CONSISTED OF AN INFINITE NUMBER OF POINTS, THOSE CIRCLES WITH THEIR POINTS COULD NOT BE URGED INTO THAT GYRATION OR SPIRAL, UNLESS ONE POINT MOVED ANOTHER FROM ITS PLACE; CONSEQUENTLY THEY COULD NOT MEET UNLESS THE POINTS IN ANY CIRCLE STOOD APART FROM ONE ANOTHER.

This is a result of the previous position. If the circles consisted of an infinite number of points then one point would easily touch another, or come into contact with it; for where there are many points it cannot but happen that some one of the points will touch another in its movement or course. For if any circle cuts another circle in two places, that is, in two opposite parts of the surface, so that the circles will of necessity cross each other—it cannot but happen, that, if the series contains a con-

siderable number, one will come into contact with another. If, say, in fig. 16, a great number of points move along the circle *aebf*, and also a great number move along the circle *acbd*, then, since the circles mutually cut each other in *a* and *b*, it must

Fig. 16.



happen that one point will reach one of the points of intersection *a* or *b* at the same moment as another point in the circle. This would take place very frequently if the points were very numerous; but, on the other hand, if they were few it would rarely happen.

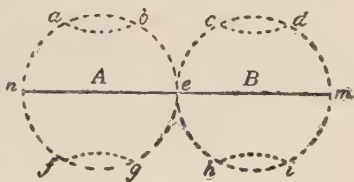
It, consequently, follows that the points will be mutually separated in their own circles, if they suitably agree. For example, let there be a hundred circles, and let each circle be traversed by its own points, then any circle will cut ninety-nine circles in two places in every revolution; or, if there are fifty circles, this will take place in forty-nine circles, or it will traverse the circles moving with it ninety-eight times. Consequently, unless the points are so situated that they in no way collide at the nodes where the circles cut one another, then they will be able to flow easily. But this cannot happen unless the points are separated by a certain distance. If this is the case, then one point can run throughout the circle connected with another point in a definite place, in which up to that time there is no point; a certain distance between the points is necessarily required.

16. IF THE POINTS ARE ECCENTRIC AND THE DISTANCE OF THE CENTRES IS EQUAL TO, OR LESS THAN THE DIAMETER OF THE SPHERE WHICH IS DESCRIBED, IT MAY HAPPEN THAT ONE POINT WILL MORE OR LESS COME INTO CONTACT WITH ANOTHER; THEY ALSO MAY NEVER MEET.

From what has been previously said it can be sufficiently understood how the points flow, and how each one separately describes the surface of its own sphere. It has also been shown that many concentric points can exist and move in one surface, and that one will not move another from its place, unless they

meet obliquely, or come into collision from opposite directions. But if they move eccentrically and to such a degree that the centre of one sphere is separated from the centre of another, by the distance equal to a diameter, so that, as in fig. 17, they are in contact at the point *e*, then let one point move throughout its own circle, or throughout its own sphere, as *abegf*, and let the other point move throughout its sphere, and its own circles, as *cdihe*, then they can never come in contact. If one point is in *b*

Fig. 17.



and another in *h*, the motion in each case being equal, and that distance being maintained when they are nearest together, then they cannot approach nearer. But here it is assumed that the point moving in the sphere *B*, and that moving in the sphere *A*, reaches each its own equator or zodiac at the same time, that is, *ne* or *em*. In this case they will certainly meet. For if one point moves forward throughout the equator or the zodiac in the sphere *B* from *m* through *B* to *e*, then the other point will be moved from *e* through *A* to *n*, and they will finally meet, although after several revolutions, for the point is carried round spirally. Consequently they are bound to meet, but on the supposition that each crosses its own equator at the same time. This may easily happen if there are several points which trace out the same sphere from the same point. The relation is the same if the

Fig. 18.

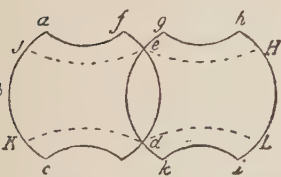


Fig. 19.

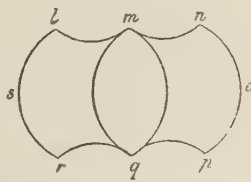
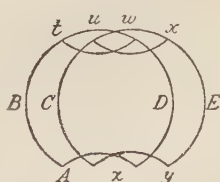


Fig. 20.



centres of the circles are distant one from another only three-quarters of a diameter, as in fig. 18, or half a diameter as in fig. 19, or a quarter of a diameter as in fig. 20, or more or less. Then

the relation is the same, provided the points meet in one circle, that is, as one point in the first sphere is in the circle Je , another in eH , or one point is in the same lower circle Kd , and the other in dL . That is to say, the points come at the same moment into those circles; then necessarily after several complete spiral revolutions they will meet, and one will displace another.

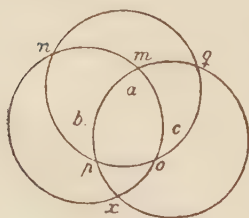
If the distance of the points is half a diameter as in fig. 19, and the points in their movement meet in the same circle, that is in the least circle of the same sphere lm and mn , then they will meet more easily still; for the smaller the circle the more easily they meet, for the space is less in which one can pass by another.

The relation is the same if the distance between the centres is still less, as in fig. 20. Then also the points will certainly meet after several complete revolutions, provided they are in the same circle, that is, if they arrive at the same moment at the same equal circle in their own sphere.

The relation is evident when a point proceeds spirally, and thus gradually moves throughout its own ecliptic; and when one point is moved from this position, the other is moved from the contrary direction, in such a way that (fig. 18) when one point passes from H to Lk in d , another is moved and transferred from c to $KJfl$; consequently they meet in d , when each is moved to a contrary part.

The relation is the same if the centres are differently situated, so that if (fig. 21) the centre of one sphere is in a , that of another in

Fig. 21.



b , and that of a third in c , then the points can meet provided they simultaneously cut the circles where these intersect, as at n, m, q, o, p, x ; consequently they are bound to meet finally. And, therefore, if many points mark out one surface, as we have previously stated, the circles are bound to correspond

in such a way that each point will arrive at the same circle at the same moment; the movement of each point will then be immediately disturbed, since one point must necessarily meet another.

17. POINTS SO ARRANGED WILL COME INTO CONTACT SOMETIMES MORE FREQUENTLY, SOMETIMES MORE RARELY.

It is quite evident from what precedes, that the points are bound to come into contact if they traverse some greater or smaller circle at the same moment, such circle corresponding to their conjunction. But as to the time, one cannot precisely demonstrate whether they will meet instantly or after an interval; retardation will depend on the distance of the point on the equator compared with the distance of another point on its own equator. For sometimes it may happen that they will meet at once; sometimes two or a hundred complete revolutions will take place, that is, two or one hundred moments may elapse before they meet. This cannot at all be reduced to calculation; for if I wished to deal with every particular, and submit everything to calculation, time would hardly permit of this. Before I submit the theory to the test of experiment, I desire to deal merely with the general argument.

Now in regard to the conjunction of lesser circles, that is, if the centres are distant one from another by any part of, but not the whole diameter, then collisions and contact of the points will more easily take place; for a point will flow through these lesser circles, and will meet and come in contact with another, which could not happen in a greater circle, for the points would pass by one another. It is, therefore, clear that the points will more easily meet when the centres of the circles are not far apart; and that they will most easily meet, if the centres of the circles are separated by only a semi-diameter. Then the circles coincide in the polar circle itself, which in respect to the remaining circles is very small. But collision will take place with more difficulty when the surfaces alone are in contact, that is when the centres are divided by a full diameter. Consequently, the periods of collision spring from the diverse situation or plane of the particles, also from the different distances of the centre.¹ All these matters you may submit to calculation if you so desire.

¹ In the margin of the MS. these words occur: "*N.B.—They do not easily meet.*"

18. VARIOUS CONSEQUENCES FOLLOW FROM THE COLLISION OF THE POINTS.

There is much variety in the collision of the points. But how they meet and the nature of the position arising therefrom, can be best stated below.¹

1. We may observe that the points flow very smoothly, and are not easily disturbed, if many are flowing round one and the same centre. Then they are so arranged with respect to one another, that about a thousand will move about their own centre, and trace out the same surface at the same time.

2. If such a surface is the result of one or several points, and all the surfaces or figures arising therefrom are mutually distant more than the length of a diameter, they will very suitably maintain their existence, and will nowhere be disturbed; for there will be no fear of collision or contact. If, however, any surface or figure is the result of several points, and are separated by a space less than a diameter, mutual disturbance will the more easily arise. For the greater the number of the points, the greater the possibility of collision, and, consequently, the greater the possibility of the disturbance of the points in the surfaces or circles.

3. If the points flow round a centre, and many such points are eccentric, then the less the distances of the centres, the more easily will they be disturbed. It has been shown above, that the further the centres recede one from another, the more easily and within a shorter time, will the points meet. The smaller the circle each one describes and the more limited the place, the more easily will contact arise on account of that limitation.

4. The aforesaid figures, that is, those which arise from the flow of the points may be in various positions with reference to one another. They may be in such a position that their centres, with respect to one another, may be in the same horizontal line, in a line forming an angle with the horizontal or perpendicular to the horizon; that is to say, one figure may be above another, the centre of one above the centre of another. Here the line which

¹ In the margin of the MS. it is written: "*N.B.—Let this be more carefully examined.*"

directly cuts the poles is called a perpendicular; the plane which passes through the equators is horizontal. It, therefore, follows that the figures may be far apart or slightly separated, and also that their centres may be respectively near to one another. Also it follows that, throughout the whole plane of the equator, as well as the plane of the poles and all other planes, the centres may have both declinatory and oblique positions; and that there may be myriads within one surface. It is evident also that an entire figure may depend on one centre only and one flowing point. Throughout the whole boundary of a single figure, it is possible that there may be centres of flowing points; it being supposed that they are so placed as to arrive at one and the same circle at the same moment; for then they are disturbed and rush into collision.

Consequently, one may conceive of these figures as if both remote and proximate in reference to one another. That is to say, myriads of such surfaces may be shut up in a narrow space, and again these myriads may be able to fill such space as can be extended and filled by them. Even if the number were increased a hundredfold or more than ten thousandfold, they could still be restricted to a narrow space, and on the other hand, the space might be vastly extended. For if a thousand points could be within the space of one or two diameters, and yet continue their own motions, and if the same points were each able to describe its own figure, were they expelled from the said space, it thence follows that the same points are able to fill, and become extended into, that vast field.

But how the figures undergo perturbation and separation with reference one to another shall be stated subsequently.

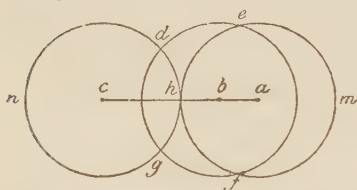
19. IF THE CENTRES ARE SLIGHTLY MOVED FORWARD WITH RESPECT TO ONE ANOTHER, IT THEN FOLLOWS THAT ALL THE POINTS WILL BE SUBJECT TO DISTURBANCE, AND THAT THE FIGURES WILL BE REARRANGED.

How these figures can be moved from place to place, and mutually recede and again return, will be shown below. For

if the universe existed from such figures, and these were not bounded by their own particles and their own vortices, they would never be able to approach to, or recede from, one another, but each would remain by itself, in its own place. But since it is the vortices that bound such surfaces, and give quality to any place, they can mutually approach and recede; of which more in what follows.

Here we will merely state that all the surfaces, however many they may be, can be displaced, and all the points driven and urged into other places, provided that, as to their centres, they approach to, or recede from one another gradually. For the sake

Fig. 22.



of example, in fig. 22, let a be the centre of the figure $hemf$, and c the centre of the figure $ndhg$, then they meet only in the point h . If the points in these two figures do not all arrive at their own equator at

the same moment, they will never meet. But if the figures are gradually and slowly moved forward, say from a to b , so that the figure may occupy the position $defg$, then the point of contact will be transferred from h to d , and, in the course of being transferred, the point of contact will be found at all places in the figure between h and d , and at length it will be found in de or gf as the circle to which the point of each figure arrives at the same time. For it cannot but happen that at length contacts will take place in this circle, since these points of contact move forward gradually in such a way that there is no place, or no circle, in the circumference where the surfaces are not in contact. At length, therefore, contact will take place in that circle, and at that place where both points arrive at the same moment. It follows, then, from the previous rule, in regard to collision, that one will drive another from its place; but the approach of the centres will be quite slow. The truth of this proposition stands, therefore, that if the centres mutually approach, or if

they recede slowly, it cannot but happen that one point will flow against another, and one will drive another from its place, and that then a different arrangement of the figures and surfaces will take place, or a kind of extension or amplication.

This will become the more evident if there are several such surfaces, or if there are several points in one surface; for then the perturbation will be greater, and, as it were, the force and conflict will be greater, also the changes of place and transposition.

20. IF IN THE EQUATOR OF EACH CIRCLE THE POINTS DIRECTLY MEET, NO CHANGE IN THE FIGURE WILL ARISE; BUT THERE WILL BE A SUDDEN ALTERATION, AS IT WERE, IN THE SAME.

It is well known that, if two spherical bodies meet in a direct line, as, for example, in fig. 23, if b and c meet in this way;

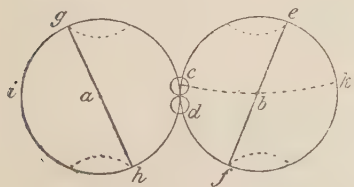
Fig. 23.

that is to say, if the body c meets the other in the direction dc , and the body b proceeds from a to b , $a-----\overset{b}{\bigcirc} \quad \overset{c}{\bigcirc}-----d$ they will come into collision in a direct

line. Let the motion of both be equal, then after contact they will recede along the same line, that is, c to d and

b to a . Similarly, if, in fig. 24, two points meet, as c and d ; that is, if one point is carried from i through g to c , and the other from k through f to d , then they will come into direct contact in dc . After contact they will move in contrary directions,

Fig. 24.



d through f to k , and c through g to i . No other change will take place; each point will merely be driven along the same path in an opposite direction, the surface remaining the same, and the distance between the centres of the circles continuing the same. After a few revolutions, and after a few surfaces have been described, the points will meet again, and will be again impelled in the previous and contrary directions, and so on alternately.

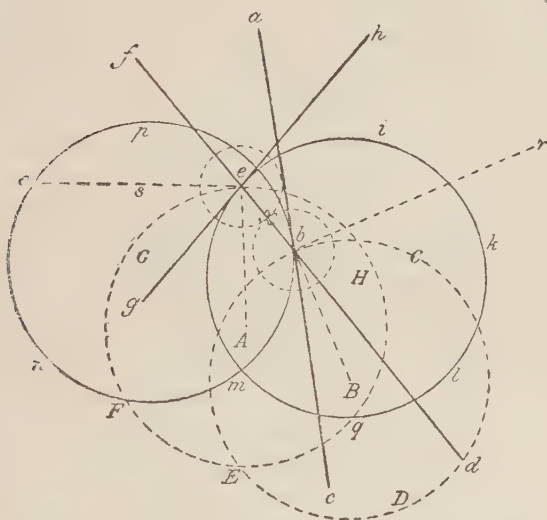
But the reason for such a sudden change in the figure will be clear hereafter. The point b of the figure is carried throughout the whole of its surface from k towards c . Similarly, when it comes to another place on its ecliptic or its equator, as in b , it will keep to the same path, that is, from b to e , and so on during its circuit. When it has thence been carried to d , that is, when it has described 180° from k , then it will continue to flow on in the same way, or from d to e to k . This flow appears to be contrary to that which it had in k towards e ; still it is the same, that is, from b towards e . If now, as a result of the force arising from impact, d is carried, not to e , but through f to k , then it will appear to be moved, as though it were in k , and were carried thence to e ; consequently, there is no change of figure; the flow of the point is the same, that is, it acquires the same motion by this recession as it had previously in k or at the distance of 180° . Such a change, therefore, can have no other result than a change in the same surface. Similarly in the case of the other figure.

21. IF THE POINTS MEET, THEY MUTUALLY RECEDE ACCORDING TO THE ANGLE AT WHICH THEY MEET, THAT IS, IN THAT DIRECTION TO WHICH THE LINE IS DRAWN, WHICH IS MIDWAY BETWEEN THE LINE JOINING THE CENTRES AND ITS TANGENT.

In the previous paragraph we have treated of the points meeting from opposite directions, and of their paths after impact. We must now consider the angular direction of the points, and their paths after impact. If they meet either in direct contact or in other circles, then it is possible for them to meet in a right line or at an angle. For the points in their meeting cannot always flow in direct opposition to one another, for it may also happen that contact takes place with other points. The points must here be considered as small spheres, whose nature they imitate, because then the demonstration will be better. Spheres are traced out by motion alone; and if such motion forms anything, the figure cannot but be most perfectly spherical.

I now assume, but I do not yet grant, that the points copy the nature of spherical bodies. It thence follows that they are variously directed according to the impact of the points that meet one another; and thus according to the rules of mechanics which are similarly obeyed in regard to other spherical bodies. That is, if the spheres meet directly or at an angle, each preserving an equal and similar motion, then the points are carried

Fig. 25.



to that part whither the line is directed, which is midway between the line joining the centres and the tangents.

Let fig. 25 be considered. The circles in which the points move are *iklqme* and *bmnop*. The points are here represented as of somewhat large size, in order that a clearer idea may be obtained. Let one point be *b* and the other *e*. Let these come into contact and meet at *x*. The points can meet at other points in the circles, but for the sake of illustration let it be at *x*. If a line be drawn through the centres of the points, as *feb*, and tangents drawn to the circles, as *heg*, tangent to the circle *iklq* at the point *e*, and *abc*, tangent to the circle *pbnm* in the point *b*, then I say that by contact their flow will be deflected

in another direction. The point b will of itself be carried upwards along the circle $pbnm$; but it is impeded by the point e and impelled in another direction, that is, from e through b towards d , or along a line passing through its centre. But since it is urged by its moving force from b to a , it consequently partakes of these two equal forces, and is borne by the resultant force along the line which bisects the angle formed between the tangent and the line passing through the centre [ab and bd] toward r .

Similarly, the point e flows along the circle $emqlk$, and collides with the point b . The tangent of the circle is hg . It has a prior motion due to its flow in the circle, or in this point along the tangent eg , and also a motion along the central line through from e to f ; consequently, the resultant motion will be from e to s and o according to rule. This resultant motion in both points is equal. The parallelogram of velocities shows the paths described after impact. The motion is not greater in one than in the other point; nor is the one subject to a greater force of impact than the other. It consequently follows that the line bisecting the angle formed by the tangent and the line through the centre of the point is in each case the new path or a new tangent through which the circle then moves.

In a similar manner, if the points do not meet, but are urged obliquely, and if many are carried round a centre, and meet in a somewhat small circle in which they have not so much room as in the equator or in some greater circle, then they are driven in a lateral direction. In respect to such urging of the points in narrow circles, there is no other rule than that which we have already referred to, namely, that the flow is determined in another direction, that is, along the median line bisecting the angle formed by the tangent and the line through the centres of the points.

22. THE MEDIAN LINE ALONG WHICH THE POINT RECEDES FROM ITS PREVIOUS POSITION IS THE TANGENT OF ANOTHER CIRCLE. IF A PERPENDICULAR BE DRAWN FROM THIS TANGENT IT WILL PASS THROUGH THE CENTRE OF A NEW CIRCLE, WHICH THE SAME POINT DESCRIBES. BY SUCH IMPACTS CIRCLES CANNOT BE DESCRIBED AT A GREATER OR LESS DISTANCE THAN A SEMI-DIAMETER, UNLESS THEY ARE MOVED FARTHER FROM THE POINT OF ANOTHER CIRCLE.

We have shown the path which the points describe after mutual impact. But since it is quite clear and evident, from what precedes, that the points cannot be carried along a right line, but in a circle and, in fact, spirally, which will be better elucidated below; therefore, when a line bisects the angle formed by the tangent and the line through the centres, it becomes a new tangent to a second circle which the points will describe, and in which they will again flow in a spiral manner. Consequently, a centre of this new sphere or this new circle can be considered.

Now let a tangent be drawn from the same place or from this new line, then the new centre will be found at the distance of a semi-diameter along the perpendicular. Let the line br , fig. 25, be that along which the flow of the point is directed after the impact; if from that line a perpendicular is drawn, that is, from b to B , then the centre of the new circle or the new sphere will be B at a distance of a radius or semi-diameter, so that the same point now describes the circle CDE , and marks out its sphere from the same centre; similarly, the point e driven by impact in the direction so . Since eso is only the tangent of a new circle, therefore, the perpendicular let fall therefrom at the distance of a semi-diameter will pass through a new centre at A , and the new circle or new sphere will be $HGFE$; whence the difference in the position of the point after various impacts will be clear.

Since the lines taking this new direction are only new tangents

for describing another circle from a different centre; and since that tangent is at the same point as the tangent of the previous circle; or since this new tangent is a tangent of the same kind in the same circle, therefore, it cannot be removed to a greater distance than a semi-diameter; it proceeds from the same place and the same circle. The motion is equal and all the circles arising from such similar motion have equal diameters. The semi-diameter of one circle is, therefore, equal to the semi-diameter of another; and consequently it cannot be at a greater or less distance than a semi-diameter; for the tangent of another circle is in the same place.

Still, however, they can be at a greater distance. If the points suffer disturbance again from another point in the places of impact, and are driven out by such impact, then they may again remove thence to the distance of a semi-diameter. As to the centres, they can be at the distance of a diameter, but no more.

23. THE PRIMARY MOTION IS ABSOLUTE MOTION, AND IT IS SPIRAL FROM THE CENTRE TO THE CIRCUMFERENCE, SO THAT IN THAT MOTION THE POSITIONS OF THE POLES ARE INFINITE AND THE GYRATION IS INFINITE; AND THE MOTION IS THAT PERTAINING TO A MOST PERFECT GYRATION; WHENCE MUST ARISE THAT OTHER SPIRAL MOTION, WHICH HAS BEEN DESCRIBED IN THE PRECEDING PAGES.

In the first chapter we said that our natural principles must begin with the first point as a kind of entity; but in the same place we stated that we were completely ignorant of the state of things before the existence of the point; and that in that state there was nothing that could come under any mechanical or geometrical rules; for there would seem to have been nothing but infinite motion or infinite qualities which could give primary existence to the natural point, since there was only absolute motion, and, in fact, infinite motion, in an infinitely small place. And yet it might be justly said that I should overstep geometry and nature herself if I wished to make geometry and her laws

extend their realm there also. Geometry acknowledges nothing but what is material. One may form a conception of a point, a line, a surface, as immaterial, still one cannot connect them with things that are plainly immaterial, and still less with things infinite. Geometry is limited to the finite. But as we have stated that the natural point, whose description we have so far given, arises from a kind of infinite motion, and that the finite owes its birth to this infinite motion, therefore, our purpose is to describe in a few words the infinity of this primary motion, although geometry cannot demonstrate it.

I do not think that this motion can be conceived otherwise than as a definite, persistent gyration from a centre to a definite periphery ; and such gyration must be regarded as spiral, and as that of a spiral turning infinitely, and tending towards its own superficies. But since it must be an altogether infinite and perfect gyration, it cannot be conceived otherwise than that from centre to periphery in such a spiral gyration all possible variations exist ; that is to say, the gyration is perfectly uniform, that it possesses infinite poles, that the flow is infinitely spiral, and that at every possible distance from the centre different poles have different spiral revolutions. But because geometry does not take account of such infinite gyration, it is difficult to bring it within the compass of words, consequently we desire to present merely a kind of idea of it. It is sufficient to state that the primary motion is absolute motion, it is that of an infinite gyration proceeding infinitely from centre to periphery, and that in such motion there are infinite poles, around which, nevertheless, revolution may be predicated. This, then, is the very origin of our natural point, which we have so far in part described.

If, therefore, the motion which gives rise to the first natural point is one of infinite gyration, so that it is bound to exert a pressure on the natural point that flows in a spiral line ; *Fig. 26.* then, for example, let this infinite primary gyration be  likened partly to *fig. 26*, where there is a centre from which the revolution is carried to the periphery and from the periphery again to the centre and thus in a perpetual spiral,

we then see that the first natural point is spherical in form.

If one may enter still more deeply into the consideration of the first motion, we must conceive that this motion proceeds spirally from the centre to the circumference, so that, nevertheless, there is no point borne from the centre to the circumference, but that it is the very motion itself which traces out such spiral surfaces, and, consequently, forms the first point which we have called the natural point. Points of two kinds therefore exist.

The first kind of point is that which naturally does not shift its centre. For if the spiral revolution commencing in the centre tends continually and with infinite motion to the circumference, and again from the circumference to the same centre, reciprocally and continuously, it follows, as a consequence, that such a point, having originated from spiral motion, rests in its own place, and that its centre is not shifted by such revolution. This spiral revolution always returns to its own centre; therefore, since there is no change or shifting of the centre, no motion round any other centre can be conceived, unless there be some impulsive force. Consequently the first point is that which does not shift its centre. This is a most natural and perfect origin.

As to the other point whose description we have given in what has gone before, it derives its origin from the same spiral motion, but that motion is only slightly different; that is to say, this spiral tends indeed from the centre to the circumference, it does not, however, tend also from the circumference to the same centre, but to another centre in the vicinity, and so on continually. It consequently flows, because the centre always keeps shifting its position, and is being moved from place to place; this is the origin of the said flow of the point.

Let fig. 27 represent the first kind of point. Let the centre be at *a*, and consequently in the spiral from *a* to *c*, *d*, *e*, *f*, *g*, *h*, *i*, *k*, *a*, and so return to the same centre at *a*; consequently, such a point cannot be shifted from place to place. But in fig. 28 the centre in *a* is moved throughout the spiral path or superficial

spirals from a to $b, c, d, e, f, g, h, i, k, l$, and so on to the centre b , not to the centre a . Consequently, it follows that such a gyration causes a continual shifting of the centre from one

Fig. 27.

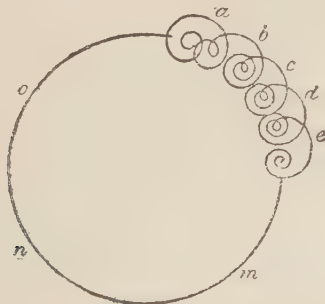


Fig. 28.



place to another, that is, from a to b , and so on perpetually; this is the origin of the natural point flowing throughout a circle. For if the centre is continually shifted, a new circle originates thence in respect to the centres, this circle being the same as the circles described from which the new surfaces arises. The flow of the natural point can be seen in some measure from fig. 29. The point of the spiral a is trans-

Fig. 29.

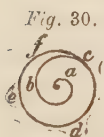


ferred to b ; so to c, d, e , that is, its centre; and so by an uninterrupted flow to m, n, o ; and so on, in agreement with the previous description.

As to the cause of this difference, that is, that one motion ceases always in the same point, or in the same centre, but that the other is transferred to a place always in the vicinity, no other reason can be assigned than that the gyration of one centre is less, while that of the other is greater. For, if the gyration is less, then, almost at the same moment the motion proceeds from the

surface to the centre, and from the centre thence to the circumference. But if the gyration is greater, then it does not pass back from the surface to the centre in the time taken by the gyration from the centre to the circumference. Consequently, the gyration of the surface to the centre should be finished in another centre, since it cannot return to the same centre; for the central gyration opposes it.

It follows from these things that the points in their flow always form a certain pole; for their spiral is a flow, and copies its own primary motion. And since the gyration from the centre to the circumference is always equal and similar to itself, and always proportionate to this motion, that is, when it reaches a certain distance from the centre, it returns again thence to the centre, and contrariwise. As there is, therefore, such an equality in this primary motion, it thence follows that the gyration in the circumference ought to be equal, since at an equal distance it comes equally to the circumference. If, in fig. 30,



it begins in *a* and proceeds therefrom through the spiral to *b* in *c*, *d*, *e*, *f* and returns again in *c*, since the extent of motion is always equal, the same point will also be in *c*, from which it returns again to the centre. It consequently follows that the superficial gyration is always the same in one point as in another; for no difference can exist here, since there can be no difference of method and order in motion and distances. As, therefore, there is the same gyration in all the surfaces of the points, the centres cannot but be always equally transferred, and all have the same flow. Thus, poles are always formed in the same place, nor can poles be in any way moved from their positions, unless the primary motion existed in another proportion. Neither can any hindrance impede this motion: if it did, the motion would be immediately renewed, and would recover itself with the help of the primary gyration.

Here we have a spacious field for explaining the nature of this primary motion, and of geometrically elucidating this spiral. For the amount of motion can be in some measure computed

and submitted to calculation. But as sufficient material for a whole volume, and indeed much more, is involved in these questions, in regard to which geometry labours in vain, I have considered it sufficient to deal with a particular aspect of the subject—of primary origin—rather than to enter that field in which every detail and every law would have to be explained. Time would not suffice for the purpose, nor is the investigation necessary; neither do those things that follow, which it is our intention to deal with, allow it. It is, consequently, sufficient to treat the subject generally. On another occasion, by the Divine aid, if there is leisure and opportunity, I should like to add to these things.

The things adduced, therefore, in this paragraph are the same as those contained in the first paragraph. I have been necessarily led to add these things, in order that the cause might be set forth whence the motion of the first natural point originated, that is, the spirial fluxion which has its own poles, which cannot be reduced to a straight line, continually preserves its own flow, is carried with equal motion, and which cannot be arrested or diminished, that is, which cannot be caused to describe a greater or less circle. For if anything resisted, still it would be borne by the primary motion into the same circle, and, by help of the said motion, it would continue to flow on for ever and with uniformity of motion. Now we must proceed to deal with questions that remain.

The primary motion may be called the most perfectly circular motion, or the circle of circles; for in one point an infinity of circles is impelled in all directions. It may also be called the motion of motions.

24. THE FLOWING NATURAL POINTS CANNOT BE SAID IN THE PRIMARY STATE TO BE TRANSFERRED FROM PLACE TO PLACE.

Let the flowing points be in the primary state, that is, in the first place, let them arise from an infinite primary motion, then they cannot be transferred from place to place; for place has no existence; there is neither upward nor downward, and as yet

no vortex ; consequently they cannot be transferred from place to place. Place derives its quality and nature from quarters, one of which looks to the north, another to the east ; or, as in any vortex, the one looks upward, another laterally, or downward. Consequently, since nothing yet exists that tends either upward or downward, space has no relativity ; and since this is the case, also no translation from place to place can be conceived. Place originates from the conception which we derive from the nature of a vortex. Since, then, no quality pertaining to place exists, place does not exist.

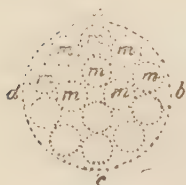
The centres of the points can indeed be transferred, in accordance with our preceding thesis ; but since in this state one point cannot possibly approach another, either approximately or remotely, there cannot, therefore, be any collision. For this reason also their movement from place to place cannot be spoken of.

25. IF THERE IS A CERTAIN SPHERE OF ACTIVITY AND THE FLOWING POINTS ARE CONFINED TO THAT SPHERE ; OR, IF THERE IS A PARTICLE TO WHICH THE PREDICATED POINTS ARE CONFINED, THEN THEY CAN BE SAID TO REST IN DEFINITE WAYS, AND TO BE TRANSFERRED FROM PLACE TO PLACE IN DEFINITE WAYS.

I will briefly explain here the nature of the change of place around these flowing points. God willing, I desire to set forth the same subject more fully as soon as the nature of a vortex has been made known.

In the first place it is supposed that these flowing points are

Fig. 31.



enclosed in a certain sphere, which has a motion of revolution ; or that they are confined to a certain particle which revolves with its enclosed points. For example, in Fig. 31, let there be a particle *abcd*, and let the flowing points *m, m, m*, be enclosed in it. (1) If the particle *abcd* is at rest, and there is no motion either

round its centre or round another centre outside the circumference, then the points *m, m, m*, are said to be at entire rest,

for they experience no movement from place to place, as there is nowhere either up or down ; and although they change the place of their centres, still they cannot be said to be moved from place to place, for place has, as yet, no existence. (2) If this particle or sphere revolved round its centre, still, since the points m, m, m , are carried along the same path and in the same revolution as the circumference, they cannot be said to be moved from place to place ; for they are at rest in their own place and follow the motion of the sphere or its surface. (3) If the particle or whole sphere makes another revolution, or moves through a circle or along a right line, still the enclosed points cannot be said to be moved from place to place, for they simply follow their own particle, or their own sphere. For if the parts, or the enclosed points, follow their own sphere by any motion whatever, still they cannot be said to be moved from place to place, but the whole sphere is moved from its place. (4) But, in fact, when the sphere or particle revolves, and all the enclosed points together with the surface, then there is a certain centrifugal tendency, and also the form of a vortex. That is, if a certain point is moved forward nearer to the centre, it is immediately carried upward and from place to place. If it is moved forward toward the surface, then it is carried downward and from place to place. If a point is carried forward more simply through a circle parallel to the sphere, it is immediately borne from place to place, equally as if it moved more slowly or more obliquely.

But these things must be more adequately explained in the following pages when the nature of the vortex is first dealt with.

26. A POINT WITH ITS QUIESCENT CENTRE MAY BE CALLED A PARTICLE OF THE FIRST KIND, OR A PRIMARY PARTICLE.

We have previously described this point and shown that it originated from pure motion. Now, since this motion is a perpetual spiral gyration from centre to circumference, and back again to the same centre, therefore, a definite point arises quiescing with its centre. This is not carried into any other circle, but remains in its own place. This point cannot be truly

said to be a particle, for it is nothing but a point that has originated from pure motion. But since we have to treat of elementary particles, and this point is the primary origin of particles, therefore, in order to have a better conception of the matter and a clearer idea, this point may be designated the *Primary Particle* or particle of the first kind, not that it is truly a particle, but that it may have a definite name, and may be distinguished from all other things.

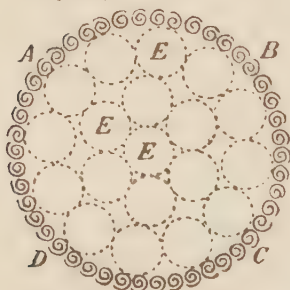
27. THE PARTICLE OF THE SECOND KIND IS THE POINT FLOWING WITH ITS CENTRE ALONG SPIRAL CIRCLES.

Let us call this flowing point, which has been sufficiently described in the preceding pages, a particle of the second kind, not because it is a particle, since there is nothing but a point. Still it gives rise to a definite particle by its own flowing movement, that is, a definite spherical form, which form we designate here, the *Primary Particle*, or particle of the first kind.

28. THE THIRD PARTICLE IS FORMED, EXTERIORLY, OF POINTS, OR PARTICLES OF THE FIRST KIND; INTERIORLY OF ENCLOSED FLUENT POINTS, OR PARTICLES OF THE SECOND KIND.

As to the third particle, which may be truly designated a particle, it is composed exteriorly of points of the first kind, but

Fig 32.



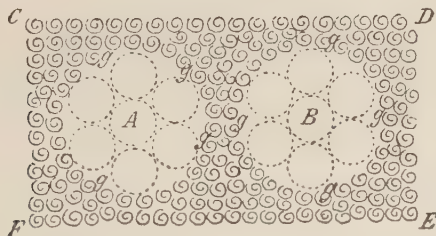
interiorly it has fluent points or particles of the second kind. How the points of the first kind coalesce to form a definite surface will be shown below; but I desire merely to indicate its composition. For it is like fig. 32, where the surface *A, B, C, D*, consists of points of the first kind, that is, of those which are at rest with reference to their own centre. Within

are enclosed the points of the second kind, *E, E, E*, which are spirally carried into circles. The position of these when moved, and their primary composition, will be seen below.

29. THE FLUENT POINTS AT LENGTH, BY THEIR OWN MOTION, SURROUND THEMSELVES WITH A SURFACE CONSISTING OF POINTS OF THE FIRST KIND.

Since the whole consists only of points of the first and second kinds, the former are at rest with reference to the centre ; but the latter change their position in reference to their centres, and, consequently, are carried through a certain circumference similar to the primary motion or spiral motion. Since, therefore, the points of the second kind are continually carried round through circles and a spiral, and nothing exists but a collection of points of the first degree, nothing else can take place but the formation of a definite surface from points of the first kind, and they will be hurried into a certain uniform motion with these included and always fluent points of the second kind. If, in fig. 33, we have a certain large space, as *CDEF*, consisting of points of the first kind, and among these also fluent points

Fig. 33.



of the second kind, as *A*, *B*, then by their own motion they will drive the resting points from them, and prepare a place for themselves among them ; this takes place naturally and mechanically. For if a certain point flows along a circle, then if anything meets it in the course of its movement, it follows that it will be driven thence ; thus that at length it will have a space in which it may freely exercise its fluent motion, as in *A* and *B*.

I might more fully prove this from geometry, but since it is

quite obvious, there is no need to waste time in useless demonstrations. Let it suffice to say that a point of the second kind will expel by its own motion a quiescent point and make a place for itself in which it will be able freely to exercise and continue its flow, as may be seen from the figure.

When, then, these mobile points have prepared a place for themselves, it is bound to happen that they will continually act against the points of the first kind, which offer an obstacle like a partition, as in *g, g, g, g, g*. When they act with a continual movement against the points which form an opposing partition, it cannot but happen that they will sensibly yield to the action, for they are passive and the included points are passive; consequently, they will be hurried by continuous action into a certain kind of motion, which is bound to be communicated to all the rest. This is the reason why definite surfaces are formed which are definitely separated from the rest, and are caused to move with the included fluent points.

From these things one may see how bodies in motion may cause other quiescent bodies to move, provided they continually rub against them. For it follows, geometrically, that a moving body will drive quiescent particles into motion provided that they are near enough to come into contact. Such particles, consequently, come into existence, as is seen in paragraph 28, where the surface consists of points of the first kind and the interior of points of the second kind.

30. THE SURFACE OF THE THIRD PARTICLE THAT HAS THUS ORIGINATED, AT LENGTH ACQUIRES THE SAME DEGREE OF VELOCITY AS THE INCLUDED FLUENT POINTS; THE SUPERFICIAL MOTION CANNOT BE MORE THAN THIS.

Since there is a continual friction and action against the particles of the surface, they are bound at length to attain the same velocity as that of the fluent points which urge them into such velocity. The motion is an impulsive one, which, if it acts against another body, causes it to have the same motion, that is, it imparts its own velocity. Conse-

quently, as the fluent point possesses almost the same dimensions as a point in the quiescent surface, the former is able easily to urge the latter into the same motion as it itself possesses, and, therefore, the entire surface.

This motion of the surface, which had originated from the motion of the included points, can in no way cease ; for if it were delayed or hindered for any period, yet, by the continual flow of the interior points, it would be gradually urged into the same velocity. Since, therefore, the moving force is confined within, and cannot cease to act, the motion also of the surface will be persistent and uninterrupted.

31. THE MOTION OF THE SURFACE, OR OF THE THIRD PARTICLE,
IS THE SAME AS THE MOTION OF THE INCLUDED POINT,
THAT IS, IT IS A SPIRAL MOTION.

This also follows from what has been previously said. For since by continuous action the fluent point impels the point quiescent in the surface, it not only must cause it to attain the same velocity, but also make it partake of the same motion. For the origin of the motion of the surface is the motion of the fluent point ; consequently, it also partakes of the same motion as that possessed by those against which it acts, as well with respect to velocity as with respect to the impact, whence also there is a spiral motion in the surface.

It consequently follows that the points on the surface and the points confined in the interior share a kind of equality, and that they are so perfectly conjoined and united in a single particle that there is nothing to disturb them. Their velocity is equal, their spiral motion is equal, and there is equality in all those things which result from the motion. When a point is moved interiorly throughout its own circle, and when it touches some point belonging to the surface, then it scarcely touches it, but it always preserves the same position in respect to the intrinsically fluent point. There is then an equality, and a kind of similitude in the motions ; consequently, these are symmetrical and harmonious.

32. IN THE SURFACE OF THIS IMPELLED PARTICLE, WE HAVE POLAR POSITION, AN EQUATOR, AN ECLIPTIC, A UNIFORM PROGRESSION ALONG THE ECLIPTIC, AND SO FORTH.

This follows from what we have previously stated. We have said that the motion in this third particle is the same as that in the second, both with regard to velocity and the very direction of motion. Whence it results from our preceding statements that the same is the case in the motion of this particle as in the motion of the prior or enclosed particle.

But since it is very necessary that the nature of this motion should be well understood, the subject must be more fully elaborated. We have previously stated with regard to this particle, that its surface consists of particles of the first kind, and that the motion of particles of the second kind causes a definite series of particles of the first kind to move in a similar way; for they are bound to follow the same motion. Since this is the case the flow will be entirely spiral, so that the particles drawn into that motion revolve in the same way as the fluent points, with this difference only, that in these particles the series of points follows the spiral motion and circumgyrates uniformly, like some screw, or the motion of the heart, as it were.

It is difficult, indeed, to explain correctly the nature of this motion; it is sufficient to say that the entire surface is carried into a definite spiral, and, both above and below, leaves vacant spaces for the poles, where no point of the surface flows. In a word, this motion is similar to the motion of the point which we have described, with this difference only, that the whole surface flows in this manner; but in the case of the point, one point only moves. A conception of the nature of this fluxional movement may be formed, therefore, from the description we have already given.

But one thing seems to be opposed to this, that, if the entire surface is urged to such a spiral gyration, it cannot be continuous and consist of continuous points. But in regard to this, I would say, that it can by no means be continuous and filled

with points, since it is in the nature of the points that the spiral motion should come from a centre and proceed to a definite circumference (fig. 34), and return again to the centre; consequently, when the spiral tends to the circumference, then it is greater and ampler; but when (fig. 35) it tends from the circumference to the centre then it is less, and more restricted. Such a point, therefore, is amplified and contracted, and expands and contracts like the lungs, or the heart.

Since then the points, of which the surface consists, are of such a nature, that they expand and contract every moment, but yet alternately, it follows, therefore, that a crowd of points in the surface does not prevent them from duly describing their own spiral; one does not act as an impediment to another.

For when these quiescent points are driven into motion by the fluent points, it necessarily follows, that they will first be driven into a gyratory movement and a kind of spiral volume, as is the case in any other element and in water itself, when urged into motion. But it proceeds gradually and by a spiral gyration, and in this gyration it can continue its own motion and preserve it perpetually.

It follows from the above that this particle of the third kind has the same motion as the fluent points, and that, like the heart and lungs, its surface infolds itself and thus undergoes perpetual changes. It also follows that the form of this particle is spherical; for the surface has a circular spiral movement, and thus is everywhere rounded up and folded upon itself.

It follows, also, that there is one polar section above and another below, in which there is no point, but which stands, as it were, open. It remains in that condition, since the enclosed points impel the surface to take up the same motion as itself, nor are they able to act toward those places where the polar sections are; for they set up the same spiral revolution, consequently there is bound to be a gap and an opening where the poles are around them to a certain distance.

It also follows that there is an equator, that is, a greater circle which cuts the particle in the middle; that there is also a zodiacal circle which cuts the spiral lines at right angles. Since there is a spiral gyration in the points, as we have pointed out, there is also this circle, that is to say, the ecliptic, which continuously but gradually shifts its points of intersection, and which has its own pole at a definite distance from the pole of the equator.

The things which have been stated in this paragraph must be considered of the greatest importance. From the above characteristic there arise then the quality and nature of the elementary particle, and many other particulars, which will be shown below.

33. THE ENCLOSED FLUENT POINTS, OR THE PARTICLES OF THE SECOND KIND, FOLLOW THE MOTION OF THE SURFACE, AND ARE FORCED ROUND SPIRALLY EVEN TO THE CENTRE.

When the surface is continually moved through a spiral gyration, the enclosed points, at least those which are nearest to the surface, will be urged into the same gyration. It is in entire agreement with the rules of mechanics, that what is enclosed follows the motion of that which encloses. The cause is the continual friction and action of the enclosed points on the surface points, as well as the reciprocal action of the surface on the enclosed points; consequently, where the surface is urged into such a gyration as we have described above, it follows also that the enclosed material, or the enclosed points, at least those which are nearest to the surface, are urged into the same gyration.

There is no need to describe this gyration, for this can be gathered from the description of that of the surface. There is the same gyration in each, with this difference only, that the enclosed points are compelled to assume that gyration; for they follow the surface, consequently they are actuated by it.

For this reason the enclosed points partake of a double motion—

one of these we have described at sufficient length in the previous pages—that is to say, it is a motion around its own centre running out into spiral circles; the other that which the enclosed points take up from the motion of the surface. For then their centres are carried round with the whole sphere of the point; to such a degree that at the same moment the point has here a double motion, one around the centre, the other in agreement with the surface, also running out into a spiral; just as all fluids do which are enclosed within some moving body, for these partake of the same motion as the moving body, and are, as it were set in motion by it. This motion cannot be really designated motion, since it follows the surface as that of a body definitely moved. As it follows its motion, the point cannot be said to be moved, but to be at rest in relation to this motion like something subservient. For what is moved by and with another thing cannot be said to be moved, but to be at rest in relation to the body in motion, just as is the case with the atmosphere in relation to the terrestrial globe, with which it moves daily in the rotation of the earth round its axis, and in its orbital path round the sun; and although it moves, nevertheless in respect to the moving body of whose motion it partakes, it nevertheless is at rest in its own vortex. So also the point can be said to be moved only in this respect, that it draws itself back from the motion of the surface and makes a somewhat retrograde effort. These things are said concerning the motion of the enclosed points which are nearest to the surface.

34. THE ENCLOSED POINTS AS FAR AS THE CENTRE ARE TOGETHER DRAWN INTO A SPIRAL GYRATION; BUT THE POINTS MORE REMOTE FROM THE SURFACE DO NOT THEN FOLLOW OR OBEY THIS MOTION; BUT GRADUALLY RETRACT THEMSELVES, WHILE THE POINT AT THE VERY CENTRE ITSELF SIMPLY TURNS ITSELF EQUATORIALLY.

There is no need for proof of the above proposition; it is sufficient to regard it as a statement applicable to every fluid. For if a vessel full of water is rotated swiftly round its centre,

then the water which is nearest the wall of the vessel will perceptibly follow the motion of the surface or wall; water which is more remote will not follow so easily, and will have less velocity, and strive to return continually to its previous state of rest, or be, as it were, drawn on by water that is moving more rapidly. We therefore see in a fluid or in water a kind of spiral dragging movement; this is made clear by experiment. The same applies to the circumstances we have mentioned above. The fluent points which are around the surface are borne somewhat swiftly, for they are hurried on by the surface itself as by a stream or by some force; but the points which are more remote from the surface gradually follow and are carried round; in such a way, however, that they are not hurried on by the same motion, for the surface does not directly act against the remoter points; but the points which are nearer the surface gradually act against these, and thus draw them into a gyration and vortex, as it were; but since the force that acts is weaker, the points do not take the same fluent motion, but gradually retract themselves. From these again a kind of spiral drag of the points arises from the surface to the centre; as is the case when water enclosed in a vessel is rotated; the same takes place with every fluid, of

Fig. 36.



whatever element it consists. As, in fig. 36, if *A* is a volume of water inclosed within any vessel, then when the vessel is rotated the water is urged into the same rotation, and draws, as it were, the interior water along with itself; but since this is driven into motion by the exterior water, it does not follow as a result of its own effort, but from compulsion, consequently that motion proceeds from the surface to the centre spirally.

As to the enclosed points, they also follow their own surface, as we have said, and indeed they partake of the same gyration as the surface; and since that gyration is spiral, according to our description, therefore also the spiral is a result of the enclosed fluid, but it slowly diminishes or retracts itself as far as the centre, so that the spiral gyration which is in the surface is, at

length, continued toward the centre, not having, however, exactly the same spiral form as that of the surface, being simpler, and, in fact, having a rotation and revolution along the circle of the equator alone.

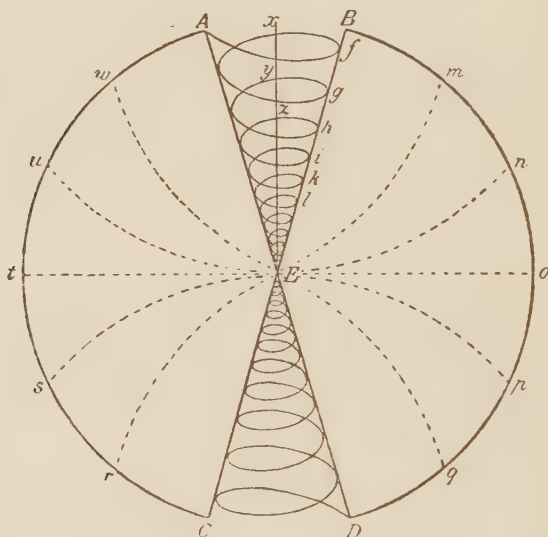
All this might, indeed, be amplified by figures and demonstrations; but it is sufficient that it agrees with experience and geometry, that the enclosed points should perform their revolution according to the gyration of the surface; but since that force is diminished, so also is the motion itself, which ends in the simple revolution in the centre. This can be proved not only in the case of water; but also in any other way. As for example, if rather long paper strips, or any other filaments that easily yield to the air, be fastened to a stick, then, when the stick is moved about in the air so as to impart a kind of spiral gyration such as we have spoken of, then the external part forms an exact spiral, in agreement with the manipulation and vibration of the stick; but the strips or threads which are in the centre are not twisted into the same spiral, but partake of a simpler motion, that is, a simpler movement of revolution.

If, now, you consider that the force of the flowing movement throughout spiral circles from the surface to the centre is gradually diminished, it follows, consequently, that, with the diminution of that force at the centre, the power of turning itself to the same spiral is diminished, the fullest action in this spiral gyration being in the greater circle. This action, as being very great and very strong, is exerted against the sphere at the centre; on the other hand, those actions being weaker that take place in smaller circles are gradually diminished, and at length vanish toward the interior parts and the centre. It therefore follows that the point flowing at the centre is urged only by the maximum force at the surface—which acts along the greater circle—that is, into a revolution along the equatorial circle.

35. THE FLUENT MATTER THAT ENTERS DOES SO THROUGH POLAR CONES AS FAR AS THE CENTRE, AND REMAINS IN THE CENTRE.

In order that the theory above stated may be the better comprehended, consider fig. 37, which represents a particle of the third kind, a description of which we have already given. The superficial points lie in the surface B, m, n, o, p, q, D and in C, r, s ,

Fig. 37.



t, u, w, A . Upon this surface the points referred to flow, and are carried round in a spiral gyration; and by such flow they form that surface and the minor circle in AB , or the polar segment in each direction; for the points cannot flow into the parts AB or CD , as we have before stated; they can flow only in the given surface.

Since the enclosed fluent points are urged by the same gyration from the surface to the centre, and since the motion toward the centre is retarded, then the following can be seen from the figure: (1) The form of the surface which the flow of the points describes;

(2) The polar gap, which ends in a kind of cone pointing to the centre from both directions ; (3) It can be seen also that the motion at the centre ends in an equal and more simple motion, in agreement with what has been stated in the preceding paragraph. For the circles *fghiklE* are merely circumferences which drive the enclosed points from the surface to the centre in the wall of the cone ; not, however, in the very body of the cone, against its walls only ; for, in this wall, the points turn toward the centre ; and this spiral vanishes in the centre and ends in a steady motion. For as the cone becomes narrower, so also the spiral circles become contracted, and, finally, terminate in an exact circle. If, then, any points, either of the first or second kind, enter that cone, so as to be near its walls, then, on account of the spiral gyration, they are deflected from the surface *A*, or the surface *B*, toward the centre, by following the deflecting stream. For that spiral stream is bound to arrive at the centre ; whether it comes from *A* or *B*, *C* or *D*, it does not cease until it comes to the centre *E*. When, now, it does reach the centre *E*, then it cannot possibly pass back again to the centre—for the gyration takes a contrary direction—but it either remains in the centre, or flows thence from *E* to *m, n, o, p, q, r, s, t, u, w*, etc. ; so that it cannot return from the centre through the poles, but must inevitably pass along a definite diameter from the centre to the circumference ; this cannot happen in the case of a particle of the third kind.

Since this particle is very small, no other matter can enter it through these polar cones, but such as is similar to the matter which is either in the surface or is enclosed in it. If the points are of the first kind, when they reach the centre, they flow from the centre to the surface, since they cannot be urged into that motion together with the enclosed central point. If there be any other point, such as a fluent point, which is carried by that gyration to the centre, then, either it remains, or it is raised up to a definite distance from the centre, and there with other points causes alternations of its own motion.

36. IN THIS PARTICLE THERE IS SOMETHING OF A CENTRIPETAL AND VORTICAL NATURE.

In regard to the centripetal and centrifugal tendency involved here, I merely desire in this connection to examine the reasons and the mode ; but when it comes to the larger vortices, I think I shall be able to show with sufficient clearness the true reasons and modes. But in regard to this particle, since it circumgyrates with a continuous motion, and the enclosed points are moved with the surface, and that motion is continued to the centre ; it is, therefore, bound to have a kind of centripetal tendency ; for unless this were the case, the particle could by no means subsist and continue its own motion. On this characteristic depends the completeness and continuance of the particle, together with the various equalities and similarities of its motion with neighbouring particles.

Fig. 38.

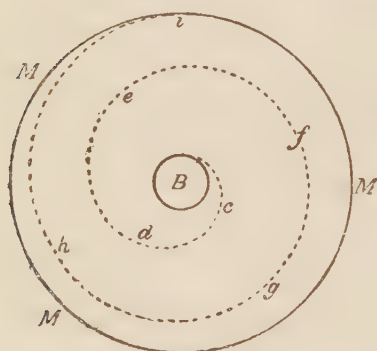
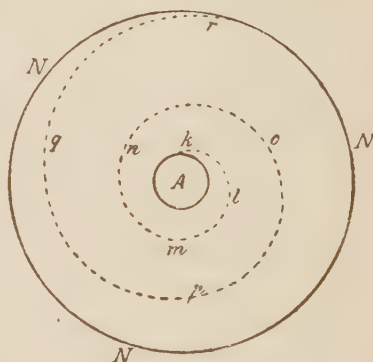


Fig. 39.

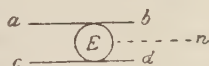


In regard to the centripetal tendency, consider, fig. 38, where the motion of the surface *MMM* draws the points, or, if one may use the term, the enclosed matter, into gyration, by a continual traction from the surface to the centre *B*. The greatest motion of the enclosed fluid is near the surface *ihgf*, but not toward the centre ; for the motion of the enclosed fluid is less there, according to the figure. It consequently follows that, if certain parts come toward the centre, where they are not so forcibly impelled, they will remain there. And if they are near the surface, as in

ihgf, because they are between the points or between the particles that are driven with the greatest motion, then they cannot be impelled in a moment with the same degree of velocity as they possess ; for this is bound to take place gradually. Consequently, since the motion among the particles is very rapid, they are driven toward that place which is most suitable either for their motion or rest. But as what we have said cannot be yet acknowledged as coming under geometry, consider

Fig. 40.

fig. 40. Let E be a certain part or spherule in the sphere of the particle discussed. The motion ab , or that motion which acts against the higher part of this globe, is more rapid than the motion which acts against the lower part cd ; for the motion which acts in the centre of the globe, as E , is so rapid that it cannot drive the globe into the same motion as itself along the same line or path in n ; for it can come gradually into the same velocity, not immediately and at the same moment as the impulsive action takes place.



Since, then, the force acting at E or the middle of the spherule has no effect, therefore the motion in the higher and lower parts ab and cd is able to exercise its utmost influence ; for it has the greatest obliquity, consequently it can there exert its particular force. Since, now, there is a greater motion or moving force in ab than in cd , it consequently follows that it is driven from the higher toward the lower part, that is, from b to d , and thus from the surface toward the centre. Therefore, since the greatest motion is nearest to the surface, and decreases gradually toward the centre, it is driven down by a greater motion from the higher to the lower part, that is, to the centre.

But if the greatest motion were nearest the centre ; as, for example, if the centre, fig. 39, revolved, and drew with it some fluid material, in such a way, however, that its gyration or motion toward the surface became slower, or, in whatever way this took place, the motion near the centre would be more rapid than that at the surface, and a definite centrifugal effect would

arise. For the rapidity of the motion acts more at the lower than the upper part, that is, more at *cd*, fig. 40, than at *ab*, consequently it is driven, of itself, as it were, from the centre toward the surface. This will be seen to be the cause of centripetal and centrifugal tendencies.

But since there is great variety here in the central and superficial velocity, its origin and continuance, also in regard to the bodies which flow into that sphere, the lightness and heaviness of those bodies in respect to the element into which they had entered, therefore, putting aside special cases, I have chosen to deal with a certain general cause. With the varieties referred to I shall deal in the proper place.

We see here that in the particle of the third kind, a sort of centripetal tendency must arise from the motion of the enclosed fluid; consequently, it follows that a kind of vortex arises. But before this can be explained, the following particulars must be considered.

37. IN THIS PARTICLE LET THERE BE A PERPENDICULAR FROM THE CENTRE TO EVERY PART OF THE SPHERICAL SURFACE, AND A HORIZONTAL LINE WHEREVER ANY PART IS CARRIED THROUGH ANY CIRCLE PARALLEL TO A CIRCLE AT THE CENTRE OR THE SURFACE. THE PROGRESSION OF ANY PART ALONG THE SAID PERPENDICULAR, OR A GREATER OR LESS PROGRESSION TOWARD ANY DEFINITE CIRCLE PARALLEL TO THE SURFACE, WHEN THE MOTION IS SPIRAL, IS MOTION FROM PLACE TO PLACE, OTHERWISE THERE IS REST.

In this particle there is a kind of vortical nature, and it is characterised by the same feature that we perceive by actual experience and observation to exist in our greater vortex of the earth. As to the perpendicular lines, and as to the necessity of their passing from the centre to the circumference, this is an evident deduction from experience. For if the motion is greater near the surface than near the centre, the body kept in that element or that sphere tends from a greater to a less velocity,

that is, it cannot be impelled in that sphere where the greater motion is, consequently it is gradually driven down to the lower parts, and indeed toward the centre. This line must be regarded as perpendicular. The direction of the action is from the circumference to the centre, and wherever a circumference exists; and since the action is the same, the striving toward the centre is the same. The degrees of velocity are diminished from the surface to the centre and almost equally throughout the whole circle, unless some difference exists, of which we can speak better below. Consequently, there must be formed a conception of place to place when there is a transference from a sphere of greater velocity to a sphere of less velocity—for heights and positions are distinguished by velocity of motion. But since one particle follows partly a definite circle, falling perpendicularly, therefore it is also carried somewhat along the circle, and in fact, describes a curve before it touches the centre; but, as to comprehending this, it can be spoken of only as a kind of perpendicular; for that which is carried along a circle with the sphere is not motion to a place, but is something lying quiescent in a fluid.

The same reason applies to a horizontal circle when the altitude is the same; but yet in a circle of the same altitude a body is carried around the centre. It cannot be said to be a circle in respect to the perpendicular lines, but a line always perpendicular, although actually it is circular.

In paragraphs 24 and 25, we have previously said, indeed, that if a body or some particle follows the stream of gyration, there is no motion—but rest. As for example, if a certain small body were floating in a circle remote from the centre, so far as to simply follow the stream of motion, moving neither too slowly nor too swiftly, it must be conceived as something lying at rest in the bosom of its own motion, like sailors in a ship, a child in the womb, and the inhabitants on the earth, although the body actually is carried round in a horizontal circle or in some other course. But since it is not moved of itself, but with and by another body, therefore it ought to be said that there is rest in the body moved.

But, in fact, if it follows somewhat more slowly, or is borne along more rapidly than the volume of the circle in the sphere, then forthwith it ought to be designated motion from place to place ; for the body is urged beyond or within that circle or movement of the sphere.

38. THE PRIMARY OR SUPERFICIAL PARTICLES ARE ALSO CARRIED TO THE SURFACE OF THE POLAR CONES.

Let us consider the figure (37) in paragraph 35. I say that the superficies *Bmnop* can be carried to the superficies of the polar cone, as in *fghikl*, as far as the centre *E*. For if interior or included matter is wanting, so that in consequence the superficies must be compressed and describe a smaller circle, then the superficial matter will be carried to those parts where there is a place for it, that is, to the opening of the cone *fgh*. For *mB* is continuous with *fg*, nor can it be carried elsewhere, because on account of the motion it cannot be broken up, but is extended to the walls of the cone, where there is still an opening, as it were.

The reasons for this can be easily given. One is that the interior surface of the cone adheres to the surface of the particle ; consequently, it is bound to follow that it will be carried, either by compression or contraction, to the wall of the cone. Another reason is, that the motion *f* to *A* is almost equal to the motion of the surface. When the motion is equal, the particle in the surface can partake of that motion, and find, as it were, its own analogue ; but still, it does not advance farther into that cone or its wall than the force of compression requires ; for it does not advance as far as the centre, unless the matter is heavier, and, adhering to the walls, acquires a certain centripetal tendency to one side. But indeed, as soon as the particle is expanded, the surface is again restored, and returns from its own cone.

39. THE MATTER AT THE SURFACE CAN BE WHIRLED AS FAR AS THE CENTRE NEAR TO THE WALLS OF THE POLAR CONES, THAT IS, FROM BOTH DIRECTIONS.

If there is a greater compression or contraction of a particle, then, for the same reason as that given in the preceding paragraph,

it may be still further whirled toward the centre. The surface is still contiguous by means of the walls of the cones as far as the centre ; but still, it does not tend thither by its own effort, but on account of the contraction and compression of the surface.

40. THE CENTRE MAY INCREASE CONSIDERABLY FROM THE SURFACE MATTER, AND THUS THE PARTICLE BE CONTRACTED AS TO ITS SURFACE.

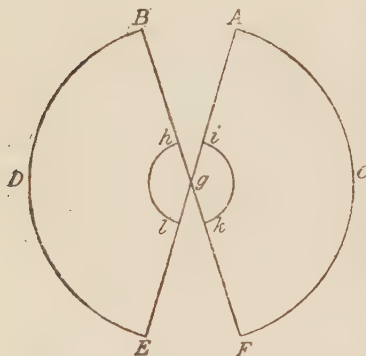
Since, therefore, the surface, by a continual flow from the circumference through the surface of the cone, is able to penetrate as far as the interior, it consequently follows that, if the force or the compression or the ejection of the enclosed matter is greater, the surface can penetrate as far as the centre, to such a degree, as to be drawn to the centre by an almost continuous nexus. Further, the compression or ejection of the enclosed material still proceeding, the surface will be still more forced to the centre, whence a kind of new centre, or an aggregation around the centre, will arise. For if a large part of the surface be driven down thither, the centre will at length have a greater and greater accretion. This is the reason why there is a very great contraction in the primary particle ; for the surface is borne to the centre, and there forms itself into a kind of globe.

41. IF THE SPHERE AT THE CENTRE IS SOMEWHAT SMALL IT WILL BE CARRIED ALONG THE EQUATOR AS THOUGH ROUND ITS OWN AXIS ; BUT IF SOMEWHAT LARGE, AND THE MATTER IS FLUENT, IT WILL MOVE VERY NEARLY INDEED ALONG THE CIRCLE AT THE EQUATOR, BUT STILL THERE WILL BE SOME STRIVING OF THE MOTION TOWARD THE POLAR SEGMENT.

If this small central sphere which has been formed from the surface matter inflowing through the polar cones, consists of fluent matter, as in this third particle, as it cannot but be—for no other matter is yet in existence—then the small central globe, arising from influx through the poles, consists entirely of fluent matter. Since then, it is fluent and the same as the surface

matter, it is bound to copy that motion which it had originated in its own place. But since the motion of this small sphere must necessarily be altogether central, let us, then, consider the origin of its motion. Consider fig. 41.

Fig. 41.



Suppose the central sphere has increased to the size indicated in the figure, in respect to the surface, *iklh*. The motion of the centre or smaller particle in the centre has previously been described, and shown to be along the equator; but if this centre increases and becomes greater as in *hikl*, then it indeed moves along the equator, since the surrounding matter does not follow the motion of its own surface, instead of that of the surface of this small sphere. For it gradually withdraws itself from that

motion into a uniform motion, along the equatorial circle, but none the less it acts upon the fluent material of which this larger small central sphere consists. Therefore, when the surrounding matter acts upon the small sphere—if this small sphere consists of fluent matter—it is bound to happen that the surface of the small sphere will, in some degree, imitate the motion of the surrounding matter, and strive to move in some spiral or in some circle through a spiral, although, nevertheless, it moves along the greater circle, that is, the equatorial circle. Consequently, there is a certain effort in the surface matter of this small sphere toward the polar cones through a slow and minute gyration.

42. AS LONG AS THE EFFORT TOWARD THE POLES PERSISTS THE CENTRAL SMALL GLOBE CANNOT BE EXACTLY SPHERICAL, BUT IT WILL BE ELLIPTICAL.

This follows from what has been previously stated; for if the small globe is carried along the equatorial circle, and definite surrounding matter always acts upon the surface of the globe

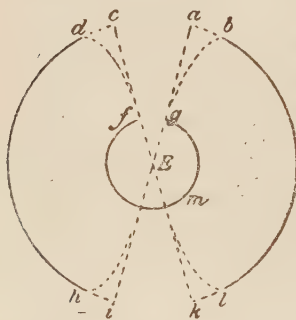
and thrusts it partly toward the globes, it follows, consequently, that part of the matter around the equator will be driven toward the poles, that is, into a kind of gyration slightly spiral. It follows necessarily that the form of the small globe will be oval, as long as the effort persists. The greater the effort, the more pronounced will be the ellipticity in a larger sphere than in a smaller one. For if the small globe be less, then it may be exactly spherical, but, if greater, then the matter forming the fluid in the small sphere will be carried to the poles, consequently there is a greater altitude there, or a greater distance from the centre. Also the larger globe becomes more oval in form; for the surrounding matter drives it somewhat forcibly into the surface of the small sphere when that is nearer to the surface itself of the small sphere. So that if the small sphere were so ample as to make the distance between the surface of the small sphere and the surface of the globe insignificant, then the motion of the surrounding matter would act violently against the surface of the large sphere. The surface of the large sphere draws its own interior matter with itself as far as the centre; but the motion gradually diminishes in agreement with the rules laid down.

But it may happen that the sphere becomes greater, that is, that the third particle formed of fluent matter may become greater; the motion of the small sphere then begins immediately to become slower, that is, the effort toward the poles decreases. For the greater the distance from the surface of the sphere, the less does the surrounding matter act upon the surface of the globe, the spiral gyration of the surface decreasing from the surface toward the centre. Consequently, when the distance of the centre is somewhat great, that force may also be diminished, and therefore the oval form of the globe may become more spherical. The same may happen if the matter between the surface of the sphere and the globe is diminished; if, then, this matter is not sufficient, it also necessarily follows that there cannot be the same force in the surrounding matter as there would be if there were abundance of matter. For this reason, the oval figure of the plane may also become spherical.

43. WHEN THE SURFACE MATTER FLOWS INTO THE CENTRE, THEN THE FORM OF THE POLAR CONES IS SOMEWHAT CHANGED.

In fig. 42, let the polar cone be either northern or southern as caE or ikE . When, now, the surface matter flows in, then the

Fig. 42.



form cannot continue to be exactly that of a cone, but the opening of the cone will be expanded so as to take the form of a hyperbolic curve. Let this be bgE/d , or on the other side Elh , having a trumpet-like form—for the matter acts from the surface as far as the centre. Hence there must necessarily be a certain curvature in b or in d , which according to calculation is a hyperbola.

But when there is no inflow from the surface to the centre, which happens when this sphere is in no way contracted, but maintains its original amplitude and dimension, then the form of the cone is represented by the surface toward the centre.

44. THE SURROUNDING MATTER, OR THAT WHICH IS ENCLOSED IN THE SAME WAY BY THE WALLS OF THE POLAR CONES, MAY FLOW TO THE CENTRE OR TO A CERTAIN DISTANCE FROM THE CENTRE.

The enclosed matter has the same flow round the polar cones ; for the motion of that matter is the same as the flow of the surface matter, with this difference only, that it is gradually diminished toward the centre. And since the motion is the same, and there is great compression, therefore this also may extend to the poles, and follow in the same direction as the surface material. The cause and reason is the same for both.

45. THE HEAVIER MATTER SEEKS THE CENTRE AND THE LIGHTER THE SURFACE, WHENCE THE SPHERE IS DIFFERENTIATED IN SUCH A WAY THAT THE HEAVIEST MATERIAL SETTLES AT THE CENTRE, WHILE THE LIGHTER GRADUALLY RECEDES FROM THE CENTRE.

This is a result of what has gone before. Heavier materials seek the centre for there is a centripetal tendency, while the lighter materials seek the surface. This, indeed, is not a matter of chance, since this sphere or third particle consists of two kinds of particles, that is to say, of those which lie in the surface, and those which are enclosed within. It is clear enough from what has gone before that the heavier materials seek the centre. If the lighter enclosed matter insinuates itself through the spirals of the cones toward the interior globe, it is bound to go to the surface of the globe, because the matter is lighter; it cannot penetrate to the denser parts. Thus the difference between the lightness of the materials is proportional to the distances from the centre.

But it is not worth while to treat this point further; what we have said is sufficient in a general way.

46. THE POLAR CONES MAY ALSO BE FILLED WITH FLUENT MATERIAL.

The polar cones open out considerably, and have sufficient space, so that some matter can have place in it, consequently it can be entirely filled with matter. But that the matter, or that which is enclosed in the sphere, is fluent, will be shown below.

47. THE MOTION OF THE MATTER IN THE POLAR CONES IS A SPIRAL MOTION ROUND THE AXIS TOWARD THE CENTRE, WHERE IT IS TERMINATED IN THE CIRCLE WHOSE DIAMETER IS PERPENDICULAR TO THE AXIS OF THE POLE.

Let figure 37, in paragraph 35, be consulted. Consider the motion of this spiral sphere; first the motion of the surface, which is deflected round the poles, and thus reciprocally brings its own

deflections into the form of the spiral first described ; and understand that the enclosed matter—in a kind of helix, as far as the centre, is drawn into almost the same motion, that is, it is drawn from the circumference into a spiral in almost the same, but a slower way, then it evidently follows, that the deflected matter both in the surface and within is transmitted to the walls of the cones *f, g, h, i, k, l*, in such a way that the motion gradually decreases from *f* to *l* ; if, therefore, you examine the circles of the cone or the interior surface of the cone, it will be seen that the motion is there directed into a kind of spiral along the path of the circumfluent matter, that is, into that form which the figure in the above paragraph represents. For not only is the motion directed throughout that form, but also the velocity. The velocity is greater in the upper part than in the lower, although the revolution is more frequent.

But, in fact, round the centre the motion is not only slower, but it almost vanishes ; consequently it also follows that, near the centre, the motion is not spiral but circular, that is, it becomes a circle whose diameter is perpendicular to the axis. The truth of this can also be deduced from another manifest argument. There is the same gyration in the southern cone as in the northern, consequently, when the spiral action reaches the centre from each direction, the matter can no longer be driven spirally, but as a result of the meeting of the spirals from each direction the motion ends in a perfect circle.

48. THE AXIS IN THE POLAR CONES THROUGHOUT ITS WHOLE LENGTH IS THE SEAT OF A CENTRIPETAL TENDENCY.

If, therefore, the motion in the fluent matter in the polar cones is spiral, but from its summit toward the centre, it consequently follows, that the motion is greatest near the walls of the cones, as around *f, g, h, i, k, l*, and least in the centre, that is, in the axis *xyz* ; (but it is supposed here that the whole of this cone is filled with fluent matter). Since, therefore, it is least in the axis, it therefore follows that denser material is carried to the axis itself,

for the same reason that in the sphere they are carried to the centre, where also is the least motion. Hence there is a centripetal action in the axis when anything comes into this polar cone. Here it must be borne in mind that there is the same material in the sphere itself, or in the particle itself, as in the polar cones ; but there is this difference that the movement of the matter is different ; it is one thing in the sphere or particle, and another in the cone, so that they differ in motion alone. Whatever heavy material there may be in the sphere tends to the centre ; whatever material there is in the cone tends to the axis, the same condition pertaining in both ; the difference arises from the difference in the motion.

49. IN THE POLAR CONES THE REVOLUTION IS MORE RAPID
NEAR THE CENTRE THAN AT A DISTANCE THEREFROM,
BUT YET THE MOTION ITSELF IS SLOWER.

The velocity of the motion in the cones arises from the velocity of the matter in the sphere itself. Round *f*, fig. 37, the flow of the matter in the sphere is quicker than round *i* or *k* ; so also in the polar cone. But since the cone is narrower toward the lower parts, therefore, although the motion is slower, still more revolutions can be completed within the same time round the centre than more remotely therefrom. For example, let the velocity in the aperture of the cone, where the cone is widest, that is near *f*, be 100 units ; let the velocity around the centre or about *l*, be 15 units a second ; but let the greater circle at the aperture *f* have a dimension equal to 200 units, and let the circle in *l* be equal to only 5 units ; it is required to know how many revolutions the body in motion ought to complete in *l*, and where the motion is slower, when in *f* it describes one circle, where the motion is more rapid in the ratio $100 : 200 :: 15 : 30$; and when the circle in *f* has a dimension of 5 units, and at the same instant, with the given velocity or a slower motion, describes 30 revolutions, therefore $30 \div 5 = 6$, that is, there are completed in *l* six revolutions, while in *f* only one is described.

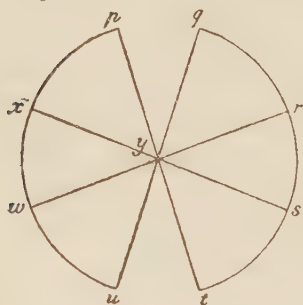
50. THERE IS A CERTAIN CENTRIPETAL TENDENCY ALONG THE AXIS AS FAR AS THE CENTRE ; BUT IT IS LESS THAN IN THE SPHERE ITSELF.

Since, therefore, the motion in the cone toward the centre is slower, it follows, consequently, that there is a certain centripetal tendency along the axis at the centre ; so that there are two centripetal tendencies in the cones, one from the surface of the cone to the axis, the other along the line of the axis to the centre of the sphere. But since the centripetal tendency must be considered from the velocity, and the spiral motion round the surface of the cone is more rapid than that along the axis, it will therefore be less in this direction, whence the bodies in the polar cone will proceed in the polar cone to the centre with slower motion than elsewhere.

51. LINES PARALLEL TO THE AXIS TERMINATE IN A TRIANGLE AT THE CENTRE.

This seems, indeed, to involve a paradox, that is, that there is a parallelism, although the lines terminate in a definite triangle.

Fig. 43.



This, indeed, can be easily shown. Take, for example, the sphere, fig. 43, frequently described, q, r, s, t, u, w, x, p . All the lines which proceed from the centre are parallels, that is, all are perpendiculars which proceed from the centre to the surface, and in that respect are reciprocally parallel, as yq, yr, ys, yt, yu, yw ; although, therefore, the

lines in that sphere, which, in respect to the sphere are by no means parallel, in respect to compression of the sphere at the centre they are parallel. It is similar in regard to the polar cones, as in fig. 44. Here all the lines $aH, bH, cH, dH, eH, fH, gH$ must be considered as parallel. The reason is, that there is the same amount of pressure at every point of such a line. For the motion

passes by spiral circles from the aperture itself to the centre, as in *algm*, or *ik* or *no*. The extent of motion from the circumference toward the axis is proportional, so that if a line falls in the third part of the circle *ag*, it also falls in the third part of the circles *ik* and *no*; and there is the same amount of motion at the same distance from the periphery, although it is slower in proportion as the circle approaches nearer to the centre. Consequently, as there is a proportionate amount, and the line passes directly through that extent of motion or those points, therefore they must be considered, in regard to the pressure, to be at the same time parallel and perpendicular.

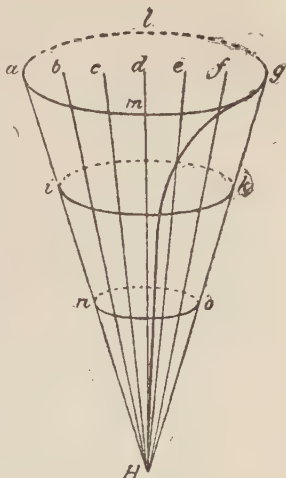


Fig. 44.

52. A HEAVY BODY IN THE POLAR CONE FALLS TO THE CENTRE ALONG A PARABOLIC LINE ; AND A LIGHT BODY ASCENDS BY THE SAME LINE.

Let fig. 44 in the preceding paragraph be considered. According to the previous statement, it is clear that there are two forces in the polar cone, one from the circumference of the cone toward the axis, which is the greatest, and the other from the aperture towards the centre, parallel to the axis. Since, then, there are two forces, and one acts more strongly than the other, therefore the path along which the body falls or ascends is a curve, that is, from *g* towards *H*, along the path there indicated.

53. THE LIGHTER MATTER SEPARATED FROM THE CENTRAL GLOBE CAN BE CARRIED TOWARD THE SURFACE OF THE SPHERE, BUT NOT BEYOND THE SPHERE EXCEPT THROUGH THE POLAR CONES.

Let it be granted that the lighter matter has followed the heavier to the centre or to the central globe, and that thence it

was separated either by motion or by any other cause whatever, then it proceeds from the surface of its globe into the sphere itself, but it cannot penetrate deeper than to the surface of the sphere. For there the matter is extremely light, and cannot pass through the surface since, this being unbroken, there is no passage. But if it proceeds from the central globe into a polar cone, then the surface offers no resistance, nor is the motion urged in a contrary direction, as in the sphere ; hence it can easily pass through, and go outside the sphere itself. Instead, therefore, of the matter of each attenuated material passing out, there is a passage only from the sphere through one pole, not elsewhere.

54. THE LIGHT OR FLUENT MATTER ENCLOSED BETWEEN THE SURFACE AND THE CENTRAL GLOBE WILL ENTER OR GO OUT BY THE POLES, AND NOWHERE ELSE ; BUT THE HEAVIER MATTER WILL REMAIN IN THE CENTRAL GLOBE, NOR CAN IT PASS OUT BY THE POLES OR BY ANY OTHER WAY.

This fluent matter enclosed between the central globe and the surface cannot be always in such abundance as to fill that cavity if the particle increases in size, nor can it be retained therein if the particle is compressed and becomes smaller. Why it may be compressed, and expanded alternately, shall be stated elsewhere. Here we shall merely say, that for whatever reason the particle is compressed or expanded, a different amount of the fluent matter will be immediately required. The enclosed matter cannot either enter or pass out through the surface, for it is evident that the matter forming the surface is continuous and cannot be penetrated. Hence it makes its exit about the centre or near the surface of the central globe to one of the polar cones ; and, since it is lighter, it ascends and so is carried beyond the particle. The polar cone is always filled with the same matter as the sphere itself, but it has a motion different from the matter contained in the sphere. Hence it is able to pass easily from the sphere into the cone, that is, to similar matter ; and to return from the cones into the sphere if necessary ; and in this way the

sphere can be emptied or filled. When it comes from the sphere into the cone, the proportion of motion is such that the higher part outside the particle can be driven down, or enter from elsewhere into the cone and thus into the sphere. There is the fountain and source, from which the matter flows, resembling in this respect the heart, through the ventricles of which the blood passes in and out; and the lungs where the blood is able to pass in and out through its own minute vessels.

But, in fact, the heavier matter, which had sought the centre will entirely settle down in the small globe near the centre; for it cannot pass out thence through the polar cones or through the matter of the fluent sphere towards the surface.¹ Here, then, there is so far no heavier and lighter matter; but because the first particles here treated of are not yet compounded, it is, therefore, still desirable to explain these points, for we are here dealing with the cone generally, and the qualities of the sphere.

55. THIS THIRD PARTICLE CAN UNDERGO CONTRACTION AND EXPANSION, AND, INDEED, MERELY BY CONTACT WITH THE ADJACENT SURFACES; FOR THERE IS NOTHING TO IMPEDE SUCH CONTRACTION OR EXPANSION, WHETHER IT BE THE SURFACE ITSELF AND ITS TEXTURE, OR THE ENCLOSED POINTS.

These particles are bound to move about their own centre, according to the preceding demonstrations. For the fluent matter which is within continually excites motion in the surface, so that it is impossible for it to be at rest as long as the motion of the interior parts continue. For the surface is urged into the gyration referred to by primary interior movements. Since, therefore, the motion of the surface cannot cease, it cannot be prevented by any obstacle from describing its own circles. If, then, there were a definite volume of particles which could be compressed by some force, concerning which we must treat below, the motion could not cease, but would continue under any pressure whatever. But when a particle is subjected to the

¹ In the margin: "This must be examined more closely."—Tr.

pressure of neighbouring particles, such pressure causes a contraction in the particle itself.

For when a surface exerts pressure upon a surface, and the motion cannot be interrupted on account of the intrinsic force, then the particle is contracted and gradually diminishes, the convexity and sphericity being preserved. Suppose, now, that there are two equal globes or balls, of such a nature that they cannot be broken, and that these can revolve round a certain axis, in such a way that their circular motion cannot cease; if they were subjected to pressure, they would be reduced to a less diameter, the motion being still preserved. The same would be the case in the above particles whose motion could in no way cease. By pressure they decrease in size, whether the pressure be great or small.

The existence of pressure will be easily granted, provided what we have previously stated be considered. The surface matter can pass through the surfaces of the polar cones into the interior parts of the cone, and, in fact, to the very centre, and form there a kind of central globe, so that, however the particle is compressed, the matter in the surface is not, as a consequence contracted, but remains in its original position, being carried to the centre only through the cones, whence, granted that there is the greatest possible pressure, its own matter is nevertheless not compressed, but is only carried into other parts, and received there.

As to this surface matter, we have previously said, indeed, that it is carried to the centre through the walls of the cones; here, now, we need merely add that it is carried equally through both cones to the centre; for the pressure in each direction is the same. Also we must repeat our previous statement, first, that the surface matter comes into the surface of the cone, and recedes somewhat from the polar circle, then that it immediately takes up a circular and spiral motion round the cones as far as the centre. For this matter takes up another motion, just as the enclosed matter does, of which we have previously spoken. Consequently, if there is a connection from the apex of the cones to the centre, then that

part which had flowed into the cone proceeds by spiral circles as far as the centre. But as soon as the particle expands and becomes larger, that part, which is in the cone, goes to its apex, and returns into that polar circle, which pertains to the revolution of the sphere itself; hence it is urged into the same motion as the surface of the sphere. We have stated the matter in this way, in order that it may be understood how the surface matter can be carried into the cones, and, indeed, into the centre itself; and, further, how it may return again into the surface, and follow the stream of that motion. But if the continuity of the surface from the apex of the cone to the centre is broken up, then the surface matter cannot return from the centre, but will remain there.

If the particle is compressed, the enclosed fluent matter can be easily forced from its own sphere into the cones; for there is nothing to prevent this taking place, according to our previous thesis. If the surface is so subject to pressure as to drive it into a narrow place, the enclosed matter is also subject to pressure, and immediately passes into the polar cone, wherein is the same matter, only moved in a different way. So, also, if the particle expands, the matter from the polar cones easily passes into the sphere or into the interior parts of the particle.

It is, therefore, sufficiently clear that the particle is capable of undergoing pressure and becoming smaller from a small amount of friction with the adjacent particles; neither can the surface material—which is only compressed by being driven to the centre—offer any resistance, nor the enclosed fluent matter, which can very easily pass in and out.

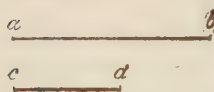
Here, also, we must observe that if the points of the second class are subject to pressure, their centres immediately undergo contraction, and when the former pass out, they may meet according to the previous thesis, and one be cast out from one place, and another from another. If any such conflict arises, and the points cannot be urged without collision in their own sphere, they are expelled, as it were, into the polar cones, where they immediately take up another motion, and are thus driven outside the sphere.

Here, too, we must observe that the included points are urged with greater motion, so that those which are near the surface betake themselves into that circle in the polar cone, in which there is the same motion, that is, the same velocity; for like betakes itself to like, and the velocity of the point into the same velocity in another place.

These brief remarks have been made concerning the contraction and expansion of this particle of the third kind. And because many things occur here, of which we have not previously spoken, therefore they will come now under consideration, as they also bear on the elucidation of what is to follow.

56. ALTHOUGH THE PARTICLE IS SMALLER, YET THE SAME VELOCITY REMAINS IN THE SURFACE; AND IN RESPECT TO THE REVOLUTIONS OF THE SURFACE THEY ARE MORE FREQUENT IN THE SMALLER THAN IN THE LARGER PARTICLE.

According to what has been previously stated, the surface is actuated by a kind of interior motion, so that it is not moved of itself, but by fluent or moving interior matter. Consequently, there cannot be a different motion in the larger particle from that in the smaller; the same velocity remains in the smaller as in the greater. Since the same velocity remains, it follows, therefore, that the revolution in the smaller particle is more frequent; just as if there were a given velocity carrying a body along the

Fig. 45.

 line *ab*, *fig 45*, and this body were carried along the line *cd*, with the same velocity. If *cd* is half the longer line *ab*, it follows that the body will traverse the former in half the time it would take to traverse

the line *ab*. In the surface of particles of this kind both greater and less, there is one equal ratio, if there is the same velocity in the greater particle, as in the less. The revolutions are more frequent in the case of the smaller particle than in that of the greater, according to our thesis.

57. THE SMALLER THE PARTICLE THE GREATER ITS INFLUENCE
UPON THE CENTRAL SMALL GLOBE.

If the particle is greater, and is impelled with the same velocity as the small one, then the enclosed matter which follows the gyration of the surface is somewhat distant from the central globe, and since the motion of the enclosed matter imitates the motion of the surface, but decreases in its gyration as far as the centre, therefore, if the surface is somewhat distinct from the central globe, then the gyration, or the action upon the globe, is slower; for the spiral traction is gradually diminished.

But if the particle is smaller, and the velocity the same, according to what has been previously stated, then the space or distance is less between the surface and the globe, whence the force and action upon the globe and its fluent matter are less. It happens that the circular motion is quicker, or that more revolutions take place in the same time in the smaller than in the greater particle. Also, that the force of gyration increases from the surface to the centre, whence it follows that the action upon the central small globe is greater if the particle is smaller, than it would be if it were greater, according to our thesis.

58. THE WHOLE SURFACE MAY BECOME A KIND OF GLOBE.

It has been shown above that the surface of the particle may be transferred into a kind of central globe by pressure and other causes, and that this globe may receive a greater and greater accretion. It has also been shown that the enclosed mobile matter may fly forth through the poles or polar cones; consequently, if there is much pressure the whole surface may pass into this globe, so that no surface particle remains, but only a globular one. Consequently, an exceedingly small particle may arise from a large one; for if any point of the surface whatever is almost infinitely small, then from the diameter of a particle which contains one thousand parts, a particle or globe may arise

consisting of only one part. The size of the globe depends on the smallness of the point contained in the surface.

59. THE CENTRAL GLOBE WITHOUT A SURFACE AND ENCLOSED MOBILE MATTER LOSES ITS OWN MOBILITY ; NOR HAS IT ANY BUT WHAT IT TAKES UP FROM THE MOTION OF THE NEIGHBOURING PARTICLES.

The motion of the central small globe arises from the motion of the surface which acts upon the enclosed particles, and these again upon the globe previously referred to. For there arises thence a certain motion of gyration in the matter of the small globe ; but when the cause ceases, the effect also ceases, nor is there any longer any such motion, but only that which may arise from the revolution of the neighbouring particles, which motion is entirely different from that which has been previously discussed. But concerning these things elsewhere.

It follows, consequently, that there is no longer any polar direction, that is, that there are no longer polar cones in such a particle, but that it is entirely spherical. For there is nothing to effect a polar direction ; the included matter is wanting, hence also, there is no conical aperture of the poles, nor in any other direction, whence it is merely spherical.

60. IT WAS SHOWN THAT BETWEEN THE PARTICLES OF THE THIRD KIND MOBILE MATTER FLOWS, OR PARTICLES OF THE SECOND KIND ; SO, ALSO, OUTSIDE THE PARTICLES OF THE THIRD KIND, PARTICLES OF THE SECOND KIND FLOW AND ARE MOVED.

Previously we have shown simply that particles of the second kind, which we otherwise have called fluent points, are enclosed in the particle of the third kind, and that they have their motion from these. But, in fact, there are certain spaces outside which cannot be empty. It consequently follows that these also are filled ; and that there is no other matter by which they can be filled than these particles or fluent points of the second

kind. These points fill all vacant spaces ; for unless such spaces are filled, there would be nothing exterior to the particle. It follows, therefore, that although these points are exterior to the particle, yet they facilitate the motion of the surface, just as the interior points do.

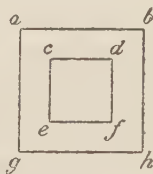
We have also said that these have an outward and inward flow through the polar cones ; whence, if the matter between the particles is deficient, it is emitted from the cones, and, if it is wanting in the particles, it is admitted through the cones ; consequently new fluent matter is sought for from the space exterior to the particles of the third kind.

61. IF PARTICLES OF THE THIRD KIND UNDERGO CONTRACTION OR DILATION, STILL THE SAME QUANTITY OF FLUENT MATTER IS REQUIRED BOTH WITHIN AND WITHOUT.

The situation of the particles is the same whether there are more or less of them ; hence the proportion of space exterior to the particles is the same as that within, whether they are large and expanded or compressed and contracted. Consequently, there is neither defect nor excess of the fluent particles, whether such particles undergo compression or expansion. It therefore follows that the amount of the fluent matter is always the same in the same space, unless there is some other reason why it should fly forth outside its own space, concerning which we shall speak below.

But understand that if (fig. 46), in the space $abgh$ there are contracted or dilated particles, yet there is still between them the same quantity of matter ; but if they are dilated, they are so compressed in $abgh$ as to include only the space $cdef$, then the included matter is in great abundance, and as much as to fill ¹

Fig. 46.

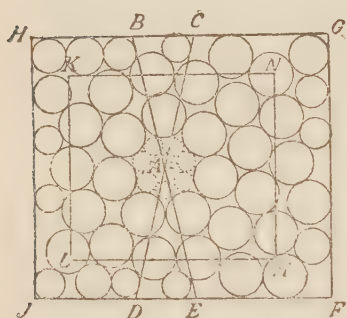


¹ This sentence stands uncompleted in the MS.

62. THE FLUENT POINTS OR PARTICLES OF THE SECOND KIND, FOR VARIOUS REASONS, MAY BE BROUGHT TOGETHER INTO ONE [PLACE] AND SEPARATELY FORM A KIND OF VOLUME, WHICH GLOBE CAN ALSO BE VERY GREATLY EXPANDED AND INCREASED.

It is evident that there is now a universe of particles of the third kind within which and exterior to which there are fluent points, or particles of the second kind. This universe must still

Fig. 47.



have its own boundaries and limits ; it cannot be extended indefinitely.

Or suppose it runs out to immensity or infinity, still there must be a reason why the fluent points are more abundant than those which had passed into the surface of the third particle ; and this must be because there is a greater quantity of fluent points of the second kind than of the first kind. For it cannot be said that there is either

equality or difference in them, or a greater abundance of one kind of matter than of another ; but it will be granted that the fluent points of the second kind are in abundance either for this or some other reason.

The points certainly ought to abound if any motion has been set up between the particles of the third kind ; and there is, consequently, a certain pressure between the particles. But since we have not yet any motion between these particles of the third kind but a spiral and gyratory one round the centre, we do not yet see any reason why these third particles should move among one another, and undergo a change of place ; we see merely that the universe is filled with them.

Hitherto nothing has been given in respect to which we can predicate altitude, perpendicular or horizontal direction, change of place, or the translation of one particle into an adjacent part ;

but there is a kind of simple plenum, constant as to its particles ; and this being granted, the particles are not yet compressed. Consequently they are all equal, nor does any particle yet exist which has in the centre a central small sphere, or which has simply taken a certain globular form. Since there was no reason why there should be compression, there was neither compression nor inequality among the particles.

I confess that in what I have said, I have spoken of compression and the variety of particles produced by means of compression ; but hitherto I have assigned no cause for such compression ; of this I shall treat below.

Let it be granted that, between the particles possessing such absolute equality, either as a result of the abundance of the points of the second kind, or for other reasons, there is a small sphere, consisting only of particles or points of the second kind as *A* in fig. 47. Let the space be small, not greater than that which would equal the space occupied by one to three particles of the third kind, and let this sphere consist of exceedingly mobile matter, or highly fluent points. Surrounding it are particles of the third kind still at perfect rest, except that they revolve spirally around their own centre, there being no motion from place to place. Since, then, there is a space between these particles, which is filled with points of the second kind, there will immediately be a primary movement amongst these particles. For they continually rub against and act upon the enveloping particles, nor do they cease so to do until they have urged them into the same kind of motion ; just as took place with regard to the surface of the particle of the third kind. When they so act, they do so not only upon the particles but even upon the identical points that are between the particles. But since the narrow space is filled with these primary mobile bodies, therefore also the action and force operative upon the surrounding particles is small too. This small force draws them into a kind of gyratory movement, at first slow, then more and more rapid. When the surrounding particles begin to be moved round this given space, or around these fluent points, and the motion is altogether

similar to the motion of the surface of each particle, the points of the second kind are unable to urge the particles into any other than their own motion, that is, into the same spiral motion which has been referred to in the previous pages.

Since, therefore, the motion is spiral, the arrangement will be the same, the poles will be the same, and entrances through the cones, that is, there will be the same form of motion as there was in the surface of the third particle. Since, then, there is a spiral motion or gyration between these particles, there will immediately arise a kind of compression; one particle will press upon another; for one particle on being moved will urge another into motion. Consequently, a certain compression arises, and from compression, according to the foregoing demonstrations, a contraction or diminution of the third particle arises, that is, it becomes less. There is a greater motion near these mobile points, or near the circumference of that space in which are the points of the second kind, therefore these are compressed into a spherical form. Hence, at the middle distance they are compressed into an intermediate size, and are there particles with central enclosed spheres; at the maximum distance there is the least motion, and, consequently, the minimum of compression; consequently, the third particles remain there almost in their own form.

It has been already explained how, from the points of the second kind, enclosed in a certain narrow space, motion among the particles may exist, and, consequently, compression and diminution of the particles. From all those things that have been previously stated, it follows that the quantity of points of the second kind is more and more abundant, and, consequently, this space *A* is increased and extended more and more, and at length becomes of the greatest magnitude.

Let the space (fig. 47) *F, G, H, J* be filled with particles of the third kind. If, now, all these particles become less by compression, either equally or unequally according to the amount of motion, then their magnitude may become less; so that the volume of particles which previously filled the space *FGHJ* now just fills the space *KLMN* or even less. It consequently follows that the

fluent matter within and between these particles, which consists of points of the second kind or of those which are in the space *A*, has not room enough between its own particles as before, and betakes itself into the space *A* either as a result of compression, or enters more remotely through the polar cones in *BC* into the central space. After the compression of the particles of the third kind this matter is abundant, and, consequently, departs thence or is left as it were derelict, and so follows the gyration of the same matter in the polar cones, and passes thither along the spiral paths.

This is the reason why the mobile sphere *A* from narrow limits increases and passes into a space which becomes greater and greater. But when the space is increased it immediately acquires a greater force, and excites motion among more particles, and to a greater distance. For if a space whose diameter is one inch, can cause a volume of one inch in diameter to revolve, a space whose diameter is 100,000 inches, will cause a volume to revolve round itself at least 100,000 inches in every direction. I have adduced this for the sake of an example, to show that that force will be increased in a greater degree than the ratio of the diameters. It will be increased more than the ratio of the cubes; on which point we shall speak elsewhere. But from these things one may conclude that from a small and insignificant origin an enormous space may be filled with this matter, or with the highly mobile points of the second kind, and thus an enormous space may be excited to motion and present in itself the nature of a vortex.

I have adduced these things merely in order that it may be understood how the first source of motion may exist in a kind of vortex, and what is the nature of that vortex.

63. THE SUN AND STARS HAD THIS ORIGIN.

It is undoubted that the sun consists of extremely attenuated matter, and that from the sun all moving bodies have their motion. According to our hypothesis, therefore, the sun could not consist of any other matter than this, of which I have given a

description in the foregoing pages. This solar ocean originated among particles in a most perfect state of rest. In taking its rise it increased and became a kind of vast sea, but not greater than its motion required, that is, to the extent to which the surrounding particles were compressed. Still, they first accumulated in one place, incited motion among the surrounding particles, and set up a gyration of a vorticle nature, of which we shall speak fully below.

This solar ocean had also its own inflow, otherwise this attenuated solar matter would have flowed partly into the vortex; thence it would have flowed back again through its own two poles, so that the solar matter flowed out through the periphery into the vortex, but flowed in again through certain poles into the sun, in a similar way to that which takes place in the case of the lungs. This matter had been forced out, but it was driven in again by another way, consequently it was in a perpetual state of motion. And first, there was a kind of movement in the particles themselves, which could not cease, and, consequently, it was bound to keep the surrounding matter moving.

But as to the rest of the stars seen to maintain a fixed position in the celestial hemisphere, they seem to have originated from the sun or star of our own mighty vortex. The magnitude of this star might arise from the greater or less inflow or accretion of highly attenuated and mobile matter. But to see the reason of the diverse magnitude of the stars, consider the following. The star, or the said solar ocean, could increase only so far as there was sufficient matter.

Let it be granted that a certain sun has arisen in a certain place in the universe, it at once urges the surrounding matter into a kind of gyre, and forms a vortex; the more it increases the greater becomes the gyration and vortex, and the greater is its acting force. Unless, then, some cause should hinder its further increase it might be vastly extended. For the greater the ocean, the greater becomes the vortex; and the greater the vortex, the more would the surrounding particles that are in

a state of motion in the vortex be compressed ; and the amount of attenuated matter flowing into the sun would be greater.

But suppose that in another part of the universe a sun or star were to originate in a similar way. This sun or star similarly forms a vortex in that place, and urges the surrounding particles into gyration. If another such star is formed at the same time, it cannot extend its vortex further than the neighbouring or lateral vortices. Consequently, the vortex being confined within limits, the compression of the particles is limited and also the growth of that sun or star is limited and arrested ; unless the neighbouring vortices acted as an impediment, it would otherwise greatly increase. It consequently follows that greater and smaller suns or stars would have been able to come into existence ; but each star, according to its magnitude, would also influence the size and amplitude of the vortex.

64. SUCH A SUN OR STAR MAY PERISH AND DISAPPEAR.

A sun or star may perish and disappear from two causes. One of these is that a neighbouring star may begin to increase, (whatever may be the cause of it) ; then that fluent matter always flows back again into its source or its own sun through the poles, and flows out again into its own vortex, and so on alternately and reciprocally. If, then, one star begins to increase, as stated, the attenuated matter, somewhat extended, flows into that greater source ; and, when this is increased, it acquires a greater power of setting up its own gyration, and in this way it deprives the neighbouring star of its supply of material, and, consequently, it will entirely perish as a result of the successive growth of the nearest star.

Another reason for the disappearance of a star that has once come into existence, is this : when two or more vortices are in its neighbourhood and exert pressure upon the intermediate vortex, whether it be new or old ; when an intermediate vortex is subject to pressure at the sides, matter of the third kind surrounding the star or its sun is at the same time subject to pressure, and, consequently, that matter enters through the poles into the

centre of the source, just as is the case with a particle of the third kind which assumes by pressure smaller dimensions, and sends its own matter down to its own centre, forming a kind of central small globe. A similar thing happens here. Matter by compression passes into the centre, and so the originant starry ocean perishes.

65. THE ORIGINANT SOLAR SOURCE REFERRED TO URGES INTO A KIND OF GYRE ALL THE SURROUNDING MATTER, WHICH CONSISTS OF PARTICLES OF THE THIRD KIND. THIS GYRE BECOMES GREATER AND GREATER ACCORDING TO THE INCREASE OF THE ORIGINANT SOURCE. THIS SPIRAL MOTION, HOWEVER, IS NEAR THE SOURCE ; BUT IT TERMINATES REMOTELY THEREFROM IN A MOTION ALMOST CIRCULAR ALONG THE ECLIPTIC.

Since these points of the second kind always act upon the surrounding matter, just as previously they acted upon the surface of the particle of the third kind, it is not to be wondered at that they set up in it a motion synchronising with their own, which must be that which the particle of the third kind possesses. That motion is spiral, flowing to definite poles and describing a polar circle, an equator and a zodiac. For the matter and motion in the particles of the second kind are the same, the cause in both is the same, consequently the effect must be precisely the same ; that is to say, the motion will be the same in the particle of the third kind, this particle having the nature of a vortex on a small scale.

The more this mobile originant source is increased and grows, the greater must necessarily be the force with which it acts upon the surrounding matter. The greater the surface, the greater the amount of active parts in the surface, and, consequently, the greater the force acting on the adjacent matter. But the greater the distance from that source, the less is the action felt by the particles, and the more slowly are they drawn into the gyration near the originant source.

The fact that the gyration which takes place somewhat remotely from the originant source, is changed from a spiral

into a kind of circular motion, is a matter requiring a deeper investigation. Although it is not our purpose to discuss the nature and motions of larger bodies, but the geometry of elementary particles, still I will briefly show the reason why a spiral motion somewhat remote from the originant source ends in a circular motion, and, indeed, in that which the ecliptic describes.

The primary spiral motion may be seen in fig. 48, where the motion follows the curve *dcb*, and does not approach nearer the pole than *a* or *b*, so that there is a certain circle *ab* or *de* within

Fig. 48.

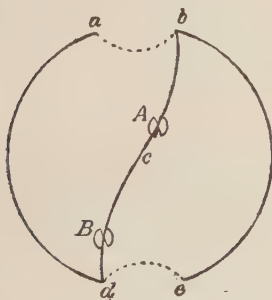
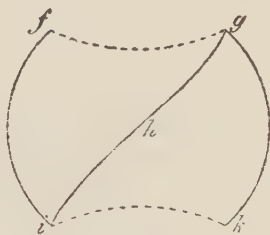


Fig. 49.



which that spiral motion does not act, but this is near the originant source. But the more remote the vortex is from that centre or source, the more does it strive naturally, as it were, to become a circular gyration, so that at a distance therefrom the gyration tends more and more to take a straight path, as in fig. 49, *ig*; therefore it approaches no nearer to the circular pole than *fg* or *ik*; and the more remote therefrom, the more does it tend to take a straight path, and the spiral traction to turn itself into a circle nearer to the equator, as in fig. 50, *onm*, so that the gyration approaches no more to the pole than is represented by the small circle *lm* or *op*. In this gyration it hastens to the end of the vortex, in which it must necessarily terminate. The reason of this is that the particles of the third kind, according to the description in the previous pages, have their own poles; that is, every particle of that kind has its own poles, and that pole always

has regard to the pole of the world, according to the demonstration in the foregoing pages. Consider fig. 51. Let z represent particles of the third kind. In the beginning or near the originant source, a volume of these particles is carried from r toward y , or, what is the same, from t toward u , or even still more to a perpendicular, if you prefer; but I adopt the former supposition. For, if the volume z were impelled from r toward y , then the particles z contained in that volume would maintain themselves in the

Fig. 50.

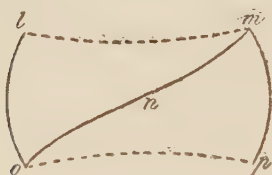
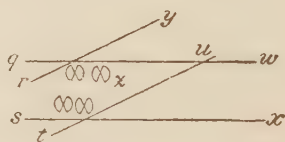


Fig. 51.



same position toward the poles as at A and B ; when they pass to another part through b , they still preserve their own situation although they may flow in a circuit. Whence it follows that one pole will be necessarily applied to another, or that the southern pole will be associated with the northern pole of the other, either wholly or partly. This, these particles, for reasons to be adduced below, do not allow, unless they perish and are dissipated. In addition, one particle will traverse several others and, in the transit, the pole of one particle will be bound to press on the pole of another. On account of such dissimilarities, which the nature of the particles possessing poles resist (concerning this, see below), they tend to gyrate in a way which agrees better with their figure.

If then the particles z (fig. 51), or their volume, flow from q toward w or from s toward x , then the pole of one particle cannot possibly meet the pole of another or touch any part of it; nor can one particle be borne in such a direction across the intervening spaces of others. But if they move in the direction shown in fig 51, as qw , or in fig. 50 om , then they will be practically carried along according to their situation; and in that motion

the pole of one will, in transit, come upon the pole of another, and it will take up a position almost like that of those particles at rest.

In a word, since the form of the particles of the third kind and their situation is according to what has been before stated, so that all the particles may have relation to the mundane pole, therefore their motion takes effect along the line in which they are situated, which is along a definite ecliptic. For it will be shown below, that the particles of the third kind can never have any polar attachment, but are only associated by a certain small circle between the ecliptic and the equator. This is the reason why, at no great distance from the originant source, the gyration thus turns itself, and immediately applies itself to the motion along a definite ecliptic; and why a gyration higher than that along the ecliptic could not proceed unless the particles were impelled by a very great motion or by considerable force. Hence the particles are naturally drawn into a gyration similar to their arrangement, and, as it were, natural to them; in which motion, too, they may be able to persist without any disruption. This seems to be the real cause of the gyration of this greater vortex along a larger circle of the ecliptic, but not along any other. These things, however, have been only briefly dealt with.

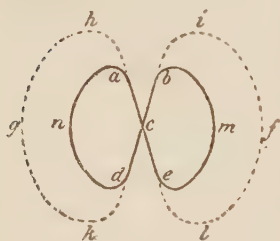
66. AROUND ALL THE PARTICLES OF THE THIRD KIND THERE
IS A KIND OF SMALL SPHERE CONSISTING OF POINTS OF
THE SECOND KIND.

It has been stated and shown above that points of the second kind are not only within the particles of the third kind, and are drawn into the same motion as the surface of that particle, but also that they are outside of it. It has not been shown, however, in what way these points flow outside the particles of the third kind. For these points are so easily influenced, that they follow the motion of another particle. They are easily drawn into that motion, so that they not only follow the motion of the

surface of the particle of the third kind within, but continue to do so because they wholly follow the motion of the same surface exteriorly; for the one is a consequence of the other. For if they follow the motion interiorly they must necessarily follow the motion of the same exteriorly. For the particles cannot have characteristics different in one place from what they are in another, provided they touch the particle or its motor surface.

It, consequently, follows that around each particle of the third kind there is a definite vortex, which almost copies the nature of the greater vortex, but nevertheless with a certain amount of difference. For example, in fig. 52, *acm* is a particle

Fig. 52.



of the third kind, in which there are points of the second kind of a highly fluent nature. Exteriorly also the matter that flows between the particles is the same, and is represented by the figures *bifle*, and *ahgkd*. This matter is drawn into a kind of spiral motion like that of the enclosed matter. Since, therefore, this matter

is drawn into the same gyration as the gyration of the surface, then it cannot possibly describe any other figure than that which will be produced by the motion itself. Around the poles *ab* and *de* there is no spiral motion, it is only in other parts. But that matter flows inward and outward through the poles *ab* and *de*; therefore it cannot be in those places, but only in those that surround the surfaces; for it is drawn by the surface into a gyration. But if there were definite material around the poles *ab*, then this would be urged into another motion, whence it would be entirely separated from the remaining matter by the adjacent figure. If anything flowed into the particle of the third kind, this would take place through the poles, and along the path in *ba* or *de*; and, similarly, if it flowed outwardly. From these things it will be seen that round a very minute particle there is formed a definite vortex, which is almost a copy of the large vortex; but, nevertheless, there is some difference.

67. WHATEVER PARTICLES OF THE THIRD KIND ARE JOINED UP WITH THEIR OWN SPHERES, OR IN WHATEVER WAY THIS TAKES PLACE, THEY NEVERTHELESS ALWAYS MAINTAIN THEIR POLAR SITUATION, NOR CAN THEY BE DIVERTED FROM IT IN ANY WAY WITHOUT RETURNING TO THE SAME SITUATION.

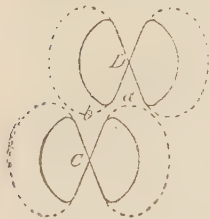
The action of the enclosed matter is such that it causes a spiral trend not directed to the pole itself of the particle. It would be superfluous to repeat here what has been previously stated. The surface is urged into the same gyration; and since the motion of the surface of the particle depends on the motion of the enclosed matter, therefore it is bound to be directed to the pole. And if the primary movement of this gyration and direction is in the enclosed matter, it necessarily follows that the direction is toward the pole, and that it cannot be shifted from that situation. For in whatever situation it may be, nevertheless one part looks to the pole. Action and direction are the same in the matter that is outside. Since then the impelling forces are both without and within, if their situation, previously referred to, is disturbed, they are certain to glide back again to the same position as before; so that however many such particles there are, they will all keep their vortices directed to the mundane pole; thus, therefore, they all maintain the same situation, whatever be the motion by which they may be actuated—in agreement with our theory.

68. POLE CANNOT BE CONJOINED WITH POLE EXCEPT AT THE DISTANCE OF THE SPHERE AROUND THE POLE.

There is, indeed, a reason why one particle of the third kind cannot be conjoined with another particle except round their ecliptics; on this point we are to treat in the following paragraph. But there is still another reason why this particle cannot be applied about the poles. If they were too closely conjoined round the poles, then the vortical matter of one would flow into the pole of another, and, consequently, into the particle itself, and while enlarging one it would leave the other empty. For example, in

fig. 53, if the particle *C* be applied to the particle *D* at the poles *b* and *a*, or in some other way, provided that the sphere of one particle enters into that of another near the poles, then *b* will

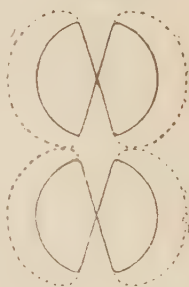
Fig. 53.



be absorbed by the particle *C* and *a* by the particle *D*, and, consequently, a single larger particle will be formed, and the circumfluent matter will be taken from the other; and when this is the case, it will completely perish unless new circumfluent matter comes to it. Also the particle will be distended; consequently it can have no relation of

motion, rest, or pressure with neighbouring particles. One, therefore, cannot be so closely conjoined with another in the neighbourhood of the poles as that the vortex of one can enter into the vortex of another. But at a distance they are capable of being conjoined, as in fig. 54, in such a way that one vortex only touches that of another. If the higher is forced downward, or they are pressed together, and one cannot yield to another, then a certain disturbance of the matter immediately takes place, and there is a disorganisation of the sphere, according to what has been previously stated.

Fig. 54.



69. PARTICLES OF THE THIRD KIND CAN BE CONJOINED ONLY ABOUT THE ECLIPTICS.

These particles, impelled by a steady motion, can be conjoined only on the condition that one does not delay another. For the particles are in continual movement; and motion takes place according to the laws previously stated, that is, spirally from one polar circle to another, and so on continually. It has also been shown previously, that the included matter and the non-included matter are urged into the same flowing movement as that of the surface. Since, therefore, not only the motion of the surface, but also that of the surrounding sphere, is spirally

urged, they will be bound to act about the ecliptic and nowhere else. For if the spiral lines are perpendicularly bisected in the centre, the circle which belongs to the ecliptic will pass through such bisection. It follows, therefore, that all spiral lines both in the surface and in the surrounding sphere will flow horizontally or perpendicularly at the ecliptic. And since the motion is alike and takes the same direction in two or more particles, then it proceeds without any delay or any hindrance. But if otherwise then the lines of motion cannot be united, but one line will be opposite to another, take a contrary or angular direction, which at once causes a delay in the motion, disturbance in the sphere, and a lesion of the particle; and by such opposite motion first the fluent particles are disturbed, then either scattered, or brought into order or their own situation.

For if they are conjoined so that the ecliptics of the particles just touch as in fig. 55, ki or XY , then the surface or its sphere will continually flow from b towards i and d ; similarly in the other part from h

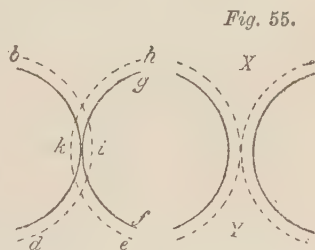
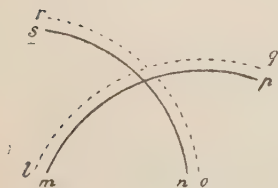


Fig. 55.

towards k to e ; consequently, they flow parallel, and the motion of one does not intersect the motion of the other

either at an angle or directly; hence they may be united in that position, or the spheres may approach somewhat closely or touch at one point. But if the motion of one intersects that of the other as in fig. 56, and sn cuts pm , then the motions of the one impedes the motion of the other. The

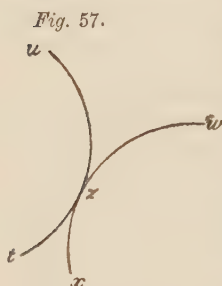
Fig. 56.



same is the case if one particle has the position ut (fig. 57) and the other wx , then the motion of the one does not respond to the motion of the other, unless in conjunction they both have the same circle.

It follows from these things that, into whatever position the par-

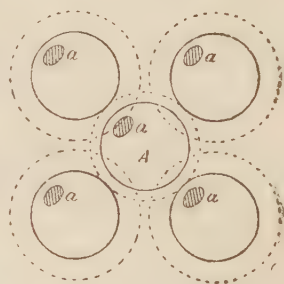
ticles flow down, unless ecliptic is joined to ecliptic, their motion will be interfered with, nor can they be adjusted with respect to that motion unless, when conjoined, they settle down along



that circle, which is always capable of responding to another and of being carried in a parallel manner upward and downward. For the same reason they cannot be united along the equator, or about the poles. Whatever circle there is, the direction of motion in one particle varies from that in another, and, consequently, collisions or a kind of conflict of motions occur, which is contrary

to the equilibrium of the particles.

Indeed this may be represented in a way by fig. 58. Let all the poles a, a, a, a, a be in a similar position; and we must conceive that they are nowhere conjoined or mutually come into contact except at the ecliptic points. In whatever direction this plane is turned, the poles will nevertheless look to the mundane pole, but they will be turned in such a manner as to be united about the ecliptic. If they were united in a different manner, conflict and opposition of motion would at once arise, which, according to geometrical laws, would be able to completely deflect the particle, impelling and pressing it into a circle.



The distance of the adjacent particles seems to be in accordance with the size of the surrounding spheres. For if the distance were somewhat less, still it would not be detrimental, because the motion is parallel and similar. But the particle which lies above approaches somewhat nearer; still the distance of the particle which lies above and of the subjacent one is greater, so that, in fact, pole does not touch pole, nor pole rest on pole.

For the better understanding of what has been previously

stated, we shall merely add that the middle particle *A* rests on the particles below, and that there is no direct contact with the ecliptic. The ecliptic is the greater circle, for if there were contact about the ecliptic, then it would not be able to rest upon the four subjacent particles, but it would be intermediate. The meaning is as follows: that it rests parallel to the ecliptic, that is, the smaller circle is parallel to the ecliptic, which is in contact with the subjacent particles, so that it is supported by those near the parallel circle of the ecliptic. And when one of the four particles makes a transit, it does so parallel to the ecliptic, and from the smaller circle to the greater, that is, to the ecliptic, and so forth. Although the circle is less, provided it is parallel to the ecliptic, the motion is nevertheless homogeneous and similar; the parallel spirals always advance and retreat, nor does anything contrary arise in the motion.

70. THE MOTION OF THE GREAT OR UNIVERSAL VORTEX PROCEEDS ALONG THE ECLIPTIC.

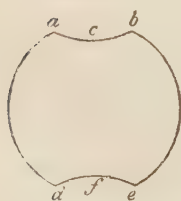
We have treated on these matters at the end of paragraph 65; but in order that a better idea may be formed, it is necessary to state the same proposition; for from the preceding statements it is clear that particles of the third kind are mutually conjoined along a definite circle parallel to the ecliptic, and that the pole of a particle always in that position looks to the mundane pole. Consequently, when a kind of vortical motion begins, it must necessarily terminate in a motion that is homogeneous with the situation of the particles. For if there were another motion, then there would be pressure according to that motion, and, consequently, the particles would be reduced to an order different from that which the motion of their surface or sphere can allow; if another, that motion would immediately offer resistance, such resistance consisting in the fact that the motion of one particle will oppose the motion of another, so that when the vortex of one comes in contact with the vortex of another, a conflict will arise from the motion of each having a contrary direction; and also there will be resistance and a consequent

lesion of the particle. If there be resistance and a resulting conflict, then, as if by a kind of force, they will be diverted into a homogeneous arrangement, that is, into one in which the motions of every particle will concur. It follows from these things that the motion of the vortex cannot terminate in any other motion than that which concurs with the arrangement of the particles; that is, a motion along the ecliptic.

71. THE ARRANGEMENT OF THE PARTICLES VARIES ACCORDING TO THE DISTANCE FROM THEIR SOURCE; THE ECLIPTIC, CHANGING THE SITUATION OF ITS OWN POLE, CONSEQUENTLY CHANGES THE POINTS OF CONTACT NOT ONLY WITH THE EQUATOR, BUT ALSO WITH THE ECLIPTICS OF THE MORE REMOTE PARTICLES. THE SAME HAPPENS IN THE MOTION OF THE LARGER VORTEX.

As to the obliquity of the situation of these particles, we must consider that there is the same obliquity in all the particles, whether they are near the centre, or very remote therefrom. The reason of this is, that the northern or polar point to which the particles look is so distant, and thence so remote, that lines drawn according to that obliquity, or along the axis of the particles, must be considered as parallel. For since there is no limit, nor is there in the universe any fixed point which may be regarded as a terminating one, but extension runs out to infinity, therefore all the particles have the same angular position, whether they are nearer the centre, or somewhat remote therefrom, near the sun, or in the extremity of its vortex. Consequently it is a sufficiently valid deduction, that all the particles

Fig. 59

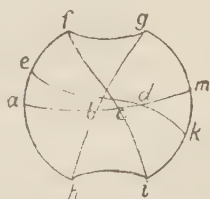


of the third kind have the same angular position, in whatever part of the vortex they may be, whether in the extremity, or lower or higher. Nevertheless, this does not prevent the pole of the ecliptic from varying, and having a difference according to the distance from the centre. The pole of the ecliptic, fig. 59, must be at a point of the segment *acb* or *dfe*;

for it cannot recede remotely from the mundane pole when it traverses the circle acb ; the pole being either a , c , or b , or elsewhere; such change or translation of the centre does not vary the position of the ecliptic so far as the mundane pole is concerned. The distance from the mundane pole, the section or degree of section of the equator, and the angular position of the particles, are always the same, the only difference being that the equator is cut in another place; if the pole is transferred into an another part of its own smallercircle, provided it be at an equal distance, and in the minor circle abc itself.

If, therefore, the large vortex had not a slower motion toward its extreme surface, but the motion were everywhere equal, then it would follow that the position of the pole of the ecliptic would be the same at every distance from the centre. But since the motion about the extreme periphery of the vortex is slower, and, near the centre more rapid, the ecliptic will necessarily alter its point of contact with the equator, or its node. For the vortex matter is continually resisting and does not easily follow its flowing movement, and only then by a kind of attraction; consequently, it is also gradually attracted from one node to another, and therefore the position of the ecliptic pole is appreciably altered. Consider fig. 60: gh , fc , ek , are various positions, of the same ecliptic, but the pole is in a different place of its circle fg , let one ecliptic cut the equator in b , another in e and a third d , then by the stated traction of the vortex, the ecliptic will change its place in respect to the equator; still the situation of the particles in their mutual contact will remain the same.

Fig. 60.



It consequently follows that if various kinds of ecliptics are compared, one will cut another, and produce nodes. This may be easily seen by those who can use globes.

The larger vortices which float in the vast solar vortex follow this current. They follow the flow of the particles and adapt themselves exactly to their situation; nor can they depart

therefrom, since there is a definite resistance which continually keeps the floating body in a circle.

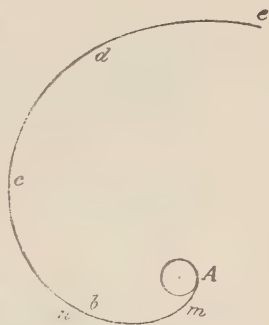
72. IN THE MOTION OF THE LARGE VORTEX THERE IS A CERTAIN PRESSURE BETWEEN THE PARTICLES, WHICH IS LESS AT A GREATER DISTANCE FROM THE SUN, AND GREATER AT A LESS DISTANCE.

When the particles are bounded by their own spheres, and those spheres have a very great velocity, then they are put in motion by a very slight pressure exerted by the neighbouring particles. For the nature of the motion is such that if a body of any kind comes into contact with it, a very strong pressure is exerted. For example, suppose that water is carried round with a certain gyration; if there is a similar vortex in the vicinity, then if they meet when the motion is very rapid, one will yield completely to the other. The same is the case in those particles which are enclosed in their small spheres, each one of these small spheres being driven round with very great velocity. It is not wonderful, therefore, that adjacent spheres under the influence of a very slight contact should be moved or subject to pressure; still more if the motion of both is not congruent, but conflicting. Therefore, when the large vortex is moved by the sun, it is not remarkable that those particles which are somewhat remote therefrom, should be driven into a large gyration, or should be moved by a very slight contact, and be very sensible to pressure. For the greater the velocity the greater is the sensibility to pressure or contact.

Since the source of motion is in the sun, and the motion near the sun is spiral and very rapid, one particle will communicate to another the motion it itself receives, and, consequently, one will exert pressure upon another. For example, if, in fig. 61, the source of motion is in *A* which sets up a gyration, then the particle in *A* exerts a pressure in *m*, and *b* in *n*, and so forth. When, therefore, the motion in *A* is very great, then the pressure on the adjacent particles is also very great, as at *m*, the velocity is greater, the number of the particles subject to pressure in the

rear, and their consequent resistance, are greater. But the remoter the particles, as in *e*, the less the pressure, the less the velocity, and the less the force; for the force decreases in proportion to the distances. This does not require many words of explanation, for in every element experiment proves the same to be the case. Sound decreases in the air in proportion to the distance; undulation in the water become less pronounced in proportion to the distance; and similarly in many other phenomena. Consequently, when a certain motion is set up, the action in the neighbourhood of the motion is very strong, and, also, the pressure exerted on the same particles, such pressure decreasing more and more according to the distance. But in what ratio the pressure decreases must be stated elsewhere.

Fig. 61.



73. BY REASON OF THE AFORESAID PRESSURE THE PARTICLES OF THE THIRD KIND SUFFER DIMINUTION, THE SURFACE LAPSING INTO A KIND OF CENTRAL GLOBE, IN CONSEQUENCE OF WHICH A PARTICLE OF ANOTHER KIND ARISES; THIS IS HERE DESIGNATED A PARTICLE OF THE FOURTH KIND.

We have referred to this particle in the preceding pages, where it has been abundantly shown that the particle of the third kind can be driven by pressure to eject a portion of its surface, and drive this down toward the centre into a kind of central globe. The particle is compressed when the vortex of one exerts pressure upon the surface of another, that is, when the particles are being acted upon in such a way that one sphere not only enters into the sphere of another, but also acts upon its surface. For if action takes place it does so near the ecliptic, whence also pressure is perceived throughout the whole surface of the particle, and, consequently, the particle forces the surface matter toward

the poles, and from the poles to the centre, according to what has been previously stated.

That a very small pressure is able to cause such diminution, has been sufficiently shown in the previous pages. But since a certain variation in the particle thence arises, it being duplicated, as it were, a portion of the surface falls into the more interior parts as far as the centre, so that this particle not only has about it its own sphere, but its surface has also a very high degree of motion, together with the sphere within, and also a kind of globe in the centre. Such a particle is a sort of microcosm; and, since it differs from the former particle, it is called a particle of the fourth kind.

74. THE GREATER THE DISTANCE FROM THE SUN OR SOURCE,
THE SMALLER IS THE SIZE OF THE CENTRAL GLOBE, AND
THE GREATER THE SURFACE, AND CONTRARIWISE.

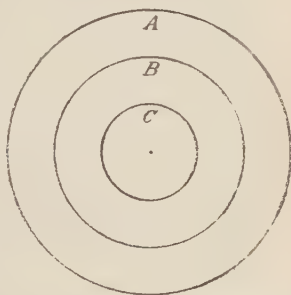
The reason of this is obvious. For the greater the motion, or the quicker the action, the greater is the pressure; and the greater the pressure the more are the particles driven into a restricted position, according to the previous paragraph. Since, therefore, the gyration is very rapid near the sun or source of motion, it follows also that the action of one particle upon another is very strong there, whence the particles are very forcibly compressed. But the pressure exerted upon the particles is not so great if they are at a distance therefrom, because the motion is less. Since the pressure accounts for the diminution of the particles or the contraction of the surfaces into a kind of central globe, therefore, according to the statement in the paragraph, it follows that the less the central globe in a particle of the fourth kind, or the greater the surface, the more distant or remote is it from the sun, and contrariwise. It may, therefore, be concluded that only the particle of the third kind is in the extreme part of the vortex, and where the vortices are in contact. In the middle of the vortex is the particle of the fourth kind, which differs according to the distances, so that the particle of the fourth kind

differs according as the extent of the enclosed globe and of the surface is small or large.¹

75. THE SMALLER THE PARTICLE OF THE FOURTH KIND, THE GREATER THE NUMBER OF REVOLUTIONS ITS SURFACE DESCRIBES IN THE SAME TIME.

This, indeed, has been pointed out in the preceding pages. Nevertheless, it is useful to repeat it here, since this particle is now the subject treated of. The reason for the above is that there are the same motion and the same velocity in a contracted as in a dilated particle. The attenuated matter which acts upon the surface within does not cease so to act until it has impelled the said surface into a motion similar to itself. If, therefore, in the smaller surface there is the same velocity as in the greater, then the smaller surface will be bound to describe more revolutions than the greater. For example, in fig. 62, let the circle *A* revolve round its centre, and also the circles *B* and *C*; if the velocity in all these were the same, then *C* would describe more revolutions than *B*, and *B* than *A*; and the velocity remaining the same, the number of the revolutions would be [inversely] as the circumferences or as the diameters.

Fig. 62.



76. THE SMALLER THE SURFACE OF THE PARTICLE OF THE FOURTH KIND, THE GREATER THE MOTION OF THE CENTRAL GLOBE; THIS MOTION FOLLOWS THE EQUATORIAL CIRCLE.

That the enclosed small sphere is carried in its revolution along the equator has been previously shown; for the spiral motion toward the centre terminates in a kind of larger circle, that is, in

¹ In the margin of the MS.: "But this refers to the primary origin of motion, the contrary is the case afterwards."

an equator. It also happens that both the attenuated matter of the second kind, and the surface matter of the first kind flow spirally toward the centre, and that this spiral path is terminated near the central globe, whence the small globe is bound to revolve round a definite axis, which axis is formed from a spiral path terminating, as it were, in a line ; for the cone is more open above than below, and below it is so attenuated as almost to be equal to a line. Unless this motion ended in a kind of axillary motion, I am not sure whether the particles would be able to rotate in the way previously shown.

As to this axillary motion in the small central globe, it may be objected that it cannot be axillary, but must be spiral and similar to the motion of the surface. But still it may be objected that the fluent points of the second kind continually act upon that small globe ; and that, since they act here in a similar way to their action upon the surface, it consequently follows that there is the same reason for motion in both. But to this objection it may be replied : (1) That not only the attenuated matter of the second kind acts upon the small central globe, but also the matter of the first kind, which flows in through the poles of the helix, and acts upon that small globe. (2) Not only may the attenuated matter of the second kind impinge upon the surface of the small globe, but also the very matter that is in the polar cones ; and since there is one kind of motion in the same matter in the cones, and another in the cavity of the particle, therefore these two motions form one simple motion in the small globe. (3) The globe is so small that points of the second kind cannot act upon the surface of so attenuated a sphere. The surface itself consists of points of the first kind. If some part of this surface becomes a single small globe, it cannot grow to a size sufficient for the matter of the second kind to be able to act upon it. The point of the second kind impels its own spiral fluxion round the centre, and, consequently, forms a kind of surface by its fluxion. The small globe could not attain such a size as to be able to drive a point of the second kind into a surface unless the whole surface became aggregated into a definite globular form.

If it be so small that one point is scarcely able to complete its revolution, still less so where many are concerned. It therefore follows that it is not urged along a spiral path, unless the globe acquires such a size that the fluent points are able to exercise upon it a certain force.

As to the velocity of its motion, I say that it is greater in proportion as the small globe is less, and contrariwise. It was shown in the previous paragraph that the motion of the surface is more rapid when the surface is of less extent than when it is greater. I do not mean that the velocity itself is greater, but that more revolutions are described in the same time. Also more revolutions are described in the small globe when of larger size, or when the surface of the fourth particle is of less extent. When the fourth particle is less and describes more revolutions in the same time, it follows that it will have a greater effect upon the enclosed globe ; such an effect, in fact, that it will cause it to rotate many times in the same period. This also will take place along the equator according to the proposition in the preceding paragraph.

77. ALL MOTION IN THE SURFACE OF A PARTICLE OF THE FOURTH KIND TENDS TOWARD THE CENTRE AND ACTS UPON THE SURFACE OF THE CENTRAL SMALL GLOBE.

There are two paths of communication between the surface of this particle and the central globe ; one directly through the surface, for the surface is continued through the polar cones, or round the walls of the cones as far as the centre ; the other through the matter enclosed between the surface and the globe. Any action on the surface is also felt in the globe. So that if there were an undulatory motion in the surface, it would traverse the whole sphere ; for it starts in a definite place under its ecliptic and extends throughout the entire surface by means of undulation. And because the surface is continuous as far as the surface of the central globe, therefore, by means of a definite unbroken connection the motion extends as far as the centre. Also there is another path of communication through the

attenuated matter referred to, when the surface is moved in a tremulous or undulatory manner. The enclosed attenuated matter moved in the same way, extends as far as the centre and causes a certain pressure in the globe, and particularly in the surface of the globe. Probably also the whole globe vibrates or trembles in a similar manner, if it is very small, and there is no yielding of the surface.

78. THE SPHERE AROUND THE COMPRESSED OR SMALLER PARTICLE, OR THAT OF THE FOURTH KIND, IS GREATER THAN THAT WHICH ENCOMPASSES THE NON-COMPRESSED PARTICLE, OR THAT OF THE THIRD KIND, CONSEQUENTLY, IT CAN BE DEFLECTED FROM ITS OWN POLAR SITUATION AND THAT OF ITS ECLIPTIC ONLY WITH VERY GREAT DIFFICULTY.

It may be called the greater sphere in this respect that it remains the same in magnitude, although the enclosed particle is compressed and decreases in size; for the attenuated enclosed matter is ejected by compression, and seeks an outlet for itself through the poles, whence the environing sphere is immediately increased in size, fresh matter being added from the interior sinus of the particle. In fact, the same amount of attenuated matter remains, but because part of it goes out to the exterior, therefore the diameter of the sphere becomes greater, if its diameter be considered as extending to the surface of the enclosed particle.

It follows from these considerations that this attenuated matter near the surface describes more revolutions than before in the same time. The smaller enclosed surface describes more revolutions, in agreement with what has been previously stated: the same is the case with the sphere lying near that surface. It can, consequently, be deflected from its polar situation only with very great difficulty, because the particles are in contact along the ecliptic. For the greater the velocity in the sphere, the less the deflection of the particles into another quarter. If one particle were deflected, there would be a contrariety of motion

and fixed in the sphere, and as the motion is rapid, therefore it would be immediately deflected into a parallel position, that is, where all the lines of the sphere flow in a parallel direction.

73 THE CENTRAL SMALL GLOBE REMAINS IN ITS OWN EQUILIBRIUM, AND MUST BE SAID TO BE WITHOUT MOTION, ALTHOUGH IT REVOLVES ALONG THE EQUATOR.

Hence the central small globe follows the motion of the surface or of its own vortex, but it gradually withdraws itself from the rapid spiral motion by the equatorial circle; consequently, when it is moved with the sphere and its surface, and elsewhere is that, as in the motion of it, it is as well, it may be said to partake of motion only in the same way as our earth truly revolves on its axis, and moves annually along the ecliptic. But we have previously dealt with these matters.

74 NEAR THE SOURCE OF MOTION, OR THE SUN, THE COMPRESSION IS SMALL GREATER, AND THE ENTIRE SURFACE BEING ONE THING, A SMALL GLOBE, SO THAT THERE IS A SMALL VORTEX GLOBE WITHIN A SURFACE SPREAD THEREFROM; THAT IS THE PARTICULAR OF THE FIRST KIND.

It is probably in the original source, round particles having a greater cohesion are found; the otherwise the particles would be carried in the surface of this source or of the sun, and would be fixed in the element of the third kind, whereas they would experience no pressure from the lateral or adjacent particles. I do not understand, therefore, those particles to be those which are in proximity to the original source, and which are found, as it were, in the element of the second kind, of which the source itself is the solar globe consists, but I speak here only of those particles which are near the source, and whose use is not separated from another, but where one is in close contact with another. Hence there is the greatest cohesion, also no fast being wanted; and from this motion the rest of the motion is the whole solar vortex arises. Therefore when the motion round the sun is very rapid and spiral, the particles will be found to experience pressure, so that no surface will remain as particles of the third and fourth

kinds, but it will form itself into a small globe. There are two or three reasons why these particles suffer pressure. The first is that the greatest amount of motion exists there, and where there is very great motion, there the pressure will be very great, and, consequently, the surface will be driven to the centre in agreement with the principles established in the preceding pages; and when the force of compression is increased, the centre is bound to be increased, and the surface diminished, until at length no surface will remain; but the small naked globe will exist which is otherwise called the small central globe.

In the second place, this motion near the sun is spiral. Thence it follows that the particles are forced to follow the motion and to be deflected not only along the pole, but also in some other direction; from this mutation a kind of conflict arises in the spheres; for unless they are in contact near the ecliptic they cannot subsist. When, therefore, the spheres are so turned that they are in contact in other points besides those of the ecliptic, not only does a conflict arise but there is a dissipation of the external sphere. Hence a path to the surface being easily afforded, the sphere being removed, as it were, from opposing it, the entire surface is easily forced into a spherical form, so that it can be established that all the particles of the third and fourth kinds, which do not follow the motion of the ecliptic—for they are urged into a kind of spiral gyre—are compressed into definite small globes bereft both of their own sphere and of a surface, at a distance from the globe.

In the third place, when the surface of the fourth kind is so compressed that there is not much distance between the surface and the small globe, then the sphere of the second kind of element cannot operate either upon the surface or upon the small enclosed globe, both being so small and attenuated, that it cannot exercise its force upon either of them. Consequently, when a particle of the third kind becomes so small, it easily, and, as it were, spontaneously, passes back into a spherical form. This small globe, because it differs from the rest, is here called a particle of the fifth kind.

81. THE SMALL GLOBE OR PARTICLE OF THE FIFTH KIND IS SO SMALL THAT MATTER OF THE SECOND KIND CAN EXERCISE NO FORCE UPON IT, BUT THE SPIRAL GYRATION PERISHES WITH THE REST OF THE QUALITIES, WHICH COME UNDER CONSIDERATION WITH REGARD TO THE PARTICLES OF THE THIRD AND FOURTH KINDS.

The compression of the particles being still further increased near the source of motion, not only are the particles urged into gyration by the very great velocity, but also they are driven from the centre towards the circumference of the vortex. As to the compression which is caused by the motion of the vortex near the originant source or sun, this is bound to be so great, since the velocity is even greater near the source than near the surface. For example, let the motion of the surface near the source be 100 degrees, and the circle which it describes be 1,000,000. In fact, about the source it is 100 degrees, although it might be 10,000, but granted that it is 100, then the circle is less, nor in respect to that dimension is it greater in the circumference than in the proportion of 1 to 1,000,000. Consequently, when one particle exerts pressure upon another, the particles do not give way, as in the large circle of the vortex, where there is an abundance of yielding particles, and so facilitate the flow without much compression. For example, let there be two lines, on one of which there are ten bladders full of air, and on the other a thousand bladders also full of air; if, now, you strike the first bladder, it will communicate the impact, or its own motion, to the ten which are suspended on the line. Similarly, if one on the other line is struck, it also communicates its own motion to the thousand others suspended on the line. The motion communicated to the ten is taken up more effectively by all because the line is so short; but the motion communicated to the one thousand bladders is not taken up so effectively, because the communicated motion is distributed over them all; the perception of motion in any part whatever, therefore, is very small.

It is similar in the particles where the circle is smaller, the

motion being nevertheless proportionately great. The greater the pressure the more fully are the particles round the source of motion, or the sun compressed into a kind of naked globe, into which the whole surface sinks. The compression is not only throughout the whole extent of that circle, but also along the radii from the sun to the circumference. Not only does the gyration extend itself to the circle, but it also acts along the diameters or the radii. Consequently, it can be easily conceived that the particles that are near the sun are very greatly compressed, this compression terminating in a kind of globe according to the foregoing theory.

82. THIS GLOBE OF THE FIFTH KIND IS SO SMALL, THAT THE ENVIRONING POINTS ARE UNABLE TO IMPART TO IT A SPIRAL MOTION.

Although the particle of the third kind is sufficiently expanded and ample, still the particle of the fifth kind or the small globe

Fig. 63.



originating from the surface is relatively quite small. For example, in fig. 63, let *CDA* represent a particle of the third kind. Nevertheless, the particle of the fourth kind is still so small as to be equal only to the small globe *A*. The reason of this is that the surface *CDE* consists only of points of the first kind, which are so small that they impart scarcely any, or a very small

breadth to the surface. Since, therefore, the surface is so small and attenuated, and since the whole surface becomes a small globe, they will give rise to a globe still smaller, so that we may almost consider it as *A* in *CDE*. For the more attenuated the surface, the less the size of the little globule to which it is able to give rise, since the whole surface passes into the spherical form.

If you choose to submit this to calculation you will see that from a very attenuated surface a very small globe may arise. But, in fact, if the surface were more extended or grosser it would be able proportionately to give rise to a larger sphere. Therefore, in considering the attenuated nature of the surface, and the smallness of the points of which the surface consists, it is not remarkable if this globe is small.

Since, therefore, this little globe is so small as to be hardly larger than the small globe which the points of the second kind produce by their fluxion, as at *B*; and since those points by their continual fluxion urge the surface *CDE* into a kind of spiral movement, therefore they cannot in the same way impel the small globe *A* into the same motion. The small globe is scarcely larger than the periphery or circumference which the points of the second kind describe; consequently, they are also able to impel it into a spiral gyration. A single point or two points of the second kind cannot impel the small globe *A* into the said gyration, but a continuous series of flowing points which continuously produce a surface ought to be able to do so. Therefore, on account of the smallness of the globe or particle of the fifth kind, it cannot be driven into that gyration by points of the second kind, which we elsewhere designate attenuated material, much less can it be kept in that state of gyration.

83. THIS SMALL GLOBE HAS THE SAME WEIGHT AS THE PARTICLE OF THE THIRD KIND; AND A VOLUME CONSISTING OF PARTICLES OF THE FIFTH KIND, OR SMALL GLOBES, IS VERY HEAVY.

One small globe of this kind equals in weight that of a single small globe of the third kind. From this it is evident that the whole surface of a particle of the third kind, where its weight resides, is concentrated in this small globe, whose weight, therefore, equals the weight of the surface. As to the attenuated matter, that is, points of the second kind, inside and outside the surface of the particle of the third kind, it can have no weight; for the point is in a state of continuous motion about a definite

centre, and cannot gravitate in any direction. But the superficies which consists of a continual series of points of the first kind will have a certain amount of weight, particularly if the whole surface is concentrated into a small globe. It is, therefore, evident that a particle of the fifth kind is equal in weight to the particle of the third kind.

It is clear from the preceding paragraph, that the particle of the third kind occupies considerable space, in comparison with the small globe or particle of the fifth kind; so that a thousand, and even more, such small globes may exist within the particle of the third kind. Since, therefore, both have the same weight, it follows that a volume consisting of a thousand particles of the fifth kind will have even still more weight than if the same volume consisted of particles of the third kind. If it were known how much space particles of the third kind occupied, and how much those of the fifth kind, it could easily be found from calculation how much weight a volume of particles of the fifth kind would have compared with a volume of particles of the third kind. It would be found that there is a great and almost enormous difference.

Since, therefore, a particle of the fifth kind is the most attenuated of all, and can in no way either undergo expansion or contraction, but is a compact body, it follows, therefrom, that a volume consisting of particles of this kind has very great weight, there being no matter in the solar world having such weight: that is, if these particles constitute one volume, or one body. But if the small globes are separated and acquire a new surface by expansion, of which we shall speak below, then much of the weight is lost.

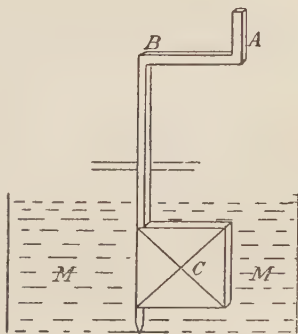
84. THIS GREAT COMPRESSION EXISTED IN THE BEGINNING OF THINGS, BEFORE THE SOLAR VORTEX WAS PERFECTLY FORMED.

As to this compression, that is, the compression of the particles of the third kind into particles of the fourth kind, and the compression of those of the fourth kind into particles of the fifth kind,

of which we are here treating, this seems to have existed fully in the primordial state of things, or at the moment when the vortex itself was being formed. In the previous pages it has been shown, that the motion originated from a kind of ocean consisting of attenuated matter, where spiral movement impelled into motion all the matters adjacent to it. It has also been shown that the greatest velocity is near that ocean, originant source, or sun. But since the surrounding matter had not yet been urged into any motion, but each particle in its own place, and at rest, produced its own gyration and its own fluxion, therefore, when that whole vortex was being urged into primary motion, greater resistance and opposition arose than when the motion was set up once for all. The case would be like that of impelling a boat of great weight on a certain course; although you pulled all the oars, and spread all the sails, you would not be able at once to get up full speed; but after a time, having been urged on its way by force of wind and sails and oars, the boat would then easily maintain its speed.

In order to make this point clearer, let, in fig. 64, *MM* be a vessel full of water. Let there be a rod with a handle *BA*; at the end let there be a flap *C*. Let the rod *B* turn about its axis by means of the handle *A*, causing the flap to revolve in the water. At first, there is a certain amount of resistance in the water, and opposition, as it were, so that a considerable amount of force is required to turn the flap *C*. But when you have turned the handle several times, then, the water having taken up the gyratory movement of the flap, the task of turning the rod becomes very easy.

Fig. 64.



The same would be the case if such a motion as this were set up in a vessel full of air. At first resistance would be felt; soon the air would be impelled to assume the same gyration as

the rod, and at length would easily follow the movement of the flap. So was it in the beginning of things, before the whole vortex could be impelled into a vortical motion. It is clear that there would be the greatest possible resistance, and, consequently, the particles would be subject to very great pressure; these particles of the fifth kind would, consequently, take their rise in the beginning.

But when the motion had extended to the extremity of the vortex, and the vortical particles had been driven into motion, then such pressure would no longer exist. For the particles would have already taken up the motion, one no longer exercising pressure upon another—except where there was still resistance, and the particles had not followed the motion—and there is only a slight but equal compression. It therefore follows that the particle of the fifth kind originated in the beginning of things, and can no longer be created. For it continues to be in the same abundance to-day as when it first came into existence, nor can any more take their rise in their own vortex.

85. THE PARTICLES OF THE FIFTH KIND CANNOT BE IN
EQUILIBRIUM WITH THE PARTICLES OF THE THIRD AND
FOURTH KIND.

The particle of the fifth kind is so small that it does not equal the one-thousandth part of a particle of the third kind, nor is it endowed with motion and a homogeneous sphere, in such a way that it can be moved at the same time as the particles of the third and fourth kind. They can occupy the interstices of the particles of the third and fourth kind, and in sufficient abundance, since there is ample space for them. But because all the particles of the third and fourth kind are surrounded with their own spheres, which are in continual motion, therefore, as soon as they come between those particles, they are immediately separated, because of the motion in such particles and in these spheres, nor can they in any way meet; so that when a particle of the fifth kind happens to flow between them, a conflict at once arises, and some amount of disturbance, on account of the great

dissimilarity, the particle being thrown aside to a considerable distance.

86. THE SUN IN THE BEGINNING OF THINGS WAS COVERED WITH A CRUST CONSISTING OF SUCH PARTICLES, AND WAS, CONSEQUENTLY, OBSCURED; THIS WAS THE ORIGIN OF SOLAR SPOTS.

Since the particles of this or the third kind could in no way preserve their equilibrium with the other particles, it is not wonderful that they constituted a definite volume, became conglomerated and occupied a place separated from the rest; and as no vortex had yet arisen, that is, as the motion of gyration had not yet penetrated to the extremity of the vortex, but was already beginning, as it were, therefore no separation of particles could exist, nor had any centripetal or centrifugal tendency yet sprung up. This characteristic came into existence with the vortex, when it was urged into regular motion, there being as yet no motion in the vortex, but only a perturbation; consequently, there could be no separation between light and heavy matters; whence this matter of the fifth kind was bound to remain in its own place; and as compression took place near the sun, therefore they occupied that place as their own, as it were, settled round it, and formed a crust. But on account of the enclosed mobile matter this crust or volume of particles of the fifth kind was bound to be perpetually urged into motion, so that that crust, by the help of the enclosed attenuated matter, was impelled to perpetually circumgyrate spirally. As to the spiral motion of this crust, we consider that the whole volume is impelled to circumgyrate spirally.

When, therefore, this crust circumgyrates spirally, it again urges the adjacent particles into motion, these again suffer compression, and the crust is augmented by a fresh accession. This augmentation continues a sufficient length of time for the whole vortex to be driven into motion. At length when the gyration has once begun, the compression is diminished, and the crust, with which the sun was obscured, underwent no further increase.

Since, therefore, such a crust of enormous magnitude surrounded the sun, it is not to be wondered at if, at that time, it was darkened, enveloped and obscured; and if one may be allowed to conjecture, one must suppose that this crust constituted the true chaos, which, when disrupted, initiated many things in the solar vortex of the planets. Thence new particles came into existence, forming the new matter which had partly settled down into their own vortices. We shall treat more fully in the following pages on this subject.

Here we see a fresh reason why new suns or new stars that have arisen in the heavens may be obscured, vanish from our sight, and be dissipated, as it were. For they may be darkened by a crust of this kind, which may also be augmented.

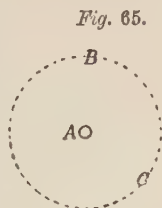
And since from this cause, matter which had constituted a vortex is absorbed, then the crust cannot but remain and the vortex disappear. It follows from this, that many stars may arise, but disappear from our sight.

This, too, is the reason why spots still appear on the sun, and do so at irregular intervals, not returning at fixed times. This results from the motion near the sun being spiral. Consequently, unless we make such a calculation as agrees with this spiral motion, we can in no wise come to a knowledge of the coming and going of these spots.

87. IN THE MEANTIME THE SUN IS INCREASED BY ATTENUATED MATTER, OR THAT OF THE THIRD KIND, UNTIL THE DISRUPTED CRUST SEPARATES.

In the previous pages it has been shown how the solar ocean arises and grows from attenuated matter, that is, when the particles suffer compression into a smaller compass, and, in fact, into particles of the fifth kind; the spheres with which these particles had been previously surrounded then recede. And since the sphere consists of particles of the second kind, or of the same matter as that of the sun, therefore so great an amount of such matter remains, and recedes from its own particles. Consequently, it is not to be wondered at that such abundant

matter should insinuate itself into the centre or that originant source either through the peripheries or the poles of the sun. For if, in fig. 65, *BC* is a particle of the third kind, which holds matter of the second kind enclosed within, so that it has a surrounding sphere consisting of matter of the same kind, then, if this whole particle *BC* yields, or is compressed into the very small body at *A*, it follows that both the enclosed and the enveloping spheres will break up; consequently, this matter is bound to be either partly enclosed between particles of the fifth kind or to recede into the solar ocean; consequently, that originant source increases; and since the increase is considerable, it is not wonderful that the crust is broken up. The cause of the disruption of the crust was not only that distention, of which mention has already been made, but also the very rapid motion of the crust which increased more and more, in proportion to the amplitude of the sun, whence the entire crust, the chaos itself, and the heterogeneous mass was bound to burst asunder and become separated.



But there is another reason why the stars which come into existence in the universe, after a time become covered with a crust, and vanish from the sight. They have an insufficiency of matter; but all that matter which had constituted the vortex formed such a crust, whence the star was able indeed to be covered with a crust, yet the fountain or star concealed within could undergo no further enlargement by reason of the want of material, for the surrounding matter passes off into the vortices of the neighbouring stars.

88. IN THE CRUST PREVIOUSLY MENTIONED, OR IN THE VOLUME OF THE PARTICLES OF THE FIFTH KIND, THERE FLOWS A CONSIDERABLE AMOUNT OF ATTENUATED MATTER OR THAT OF THE PARTICLES OF THE SECOND KIND.

There are two reasons why there is an abundance of particles of the second kind or attenuated matter between the particles of

the fifth kind or the encrusting volume of the sun. The first is, that they are in the neighbourhood of the sun, where there is a definite aggregation, and where is the ocean of those particles or matter. Therefore, since that ocean continually acts upon the crust, they will be bound to insinuate themselves on all sides between the particles of the crust, and, consequently, conceal themselves among them ; so that part of the crust will consist of particles of the fifth kind, and part of those of the second kind. They are the better able to insinuate themselves, since these are almost of the same magnitude. For the fluent points of the second kind can easily enter through the interstices of the particles of the fifth kind ; and when once they have entered, they can readily make a place for themselves by their fluxional movement. The fluent point itself is of very minute dimensions, but the circumference which the points describe by their movement is greater, consequently, they can easily enter the interstices of the particles of the fifth kind, and then by their fluxion make a place for themselves. It consequently follows that when on account of their proximity, they have come together in an ocean, as it were, they are not only able to enter among particles of almost the same magnitude, with their surface, but even to carry their motion there. Another reason is, that the particles of the third and fourth kind possess a kind of sphere consisting of such points, which sphere is both enclosed within and circumfused outside the surface of the particle. Consequently, when particles of the third and fourth kind are compressed into such a small globe, the sphere cannot immediately perish, nor can the enclosed and circumfused matter flow through ; but if the way is not open to the sun, it remains enclosed, as it were, in the volume, from which it is unable to find a way of escape. This is, consequently, a second reason why the fluent points of the second kind are enclosed in an encrusted volume, and this is in agreement with our thesis.

For if the crust consisted merely of small globes of such a kind, then it would, as a consequence, be dissipated or broken up only with difficulty, especially if the crust were somewhat

dense ; also if such matter were very heavy. Since, therefore, the crust has been disrupted, and the sun appears to us to be naked and unencumbered, it is an indication that that crust consisted of particles of the fifth kind mixed with fluent points of the second kind, or with volumes of such points.

89. MATTER OF THE SECOND KIND ACTS UPON THESE PARTICLES OF THE FIFTH KIND, IN THE SAME WAY AS IT DOES UPON PARTICLES OF THE FIRST KIND, AND DRIVES THEM INTO THOSE SURFACES, THUS BEGINNING A NEW PARTICLE, WHICH WE CALL A PARTICLE OF THE SIXTH KIND.

It has been shown in the previous pages that a small globe of the fifth kind is still so small that fluent points of the second kind can by no means act upon its surface by any revolution ; but since the small globes are so small, the points can only act upon them through points of the first kind, that is, they are able to move the small globes from place to place. Consequently, the action of the attenuated matter upon these small globes can take place only by means of the particles of the first kind ; for they are able to operate not by any kind of revolution, but by a thrusting movement, although a greater amount of attenuated matter is required here than around the first points.

Since, therefore, points of the second kind are enclosed in the encrusted volume of the particles named, according to the proposition in the preceding paragraph, they, consequently, can act only upon the surrounding particles of the fifth kind, and slowly force these into definite motion. This, although small in the beginning, takes place more easily, because they immediately give rise to a definite spiral gyration, and, consequently, form two apertures in the particle at two poles, through which matter of the same kind again flows, and this gradually enlarges the particle until it attains the proper proportions.

Further, as to the origin of this particle it necessarily follows from the preceding propositions. For since the points of the second kind possess such a motion that they have a continuous spiral flowing movement, therefore, if they are enclosed, they

perpetually act upon the surrounding particles, until at length they draw them into a definite motion, and, when this is the case, set up in them a spiral motion like their own, and so again form a particle, which, in the same way, has a very great resemblance to a particle of the third kind.

There is now, therefore, a new particle, one whose surface consists of particles of the fifth kind, and in which are enclosed fluent points of the second kind ; nor do these particles seem to differ at all from the particles of the third kind, with this exception, that they are larger, and that the surface consists of larger particles than the particles of the third kind ; of this difference we shall treat in the following pages. This particle is, therefore, called a particle of the sixth kind.

90. ALTHOUGH THE PARTICLES OF THE SIXTH KIND HAVE IN THE BEGINNING DIFFERENT MAGNITUDES, NEVERTHELESS THEY TURN OUT TO BE EQUAL WHEN THEY FORM ONE VOLUME.

These particles of the sixth kind cannot, at first, be of the same magnitude ; for the attenuated matter flows now in greater abundance, now in less. Consequently, in the procreation of particles of this kind there is variety of magnitude ; but when they form one volume, and acquire motion, then they are bound to be rendered equal both as to size and other qualities. The same matter flows between all, and attenuated matter is enclosed in all ; the same motion takes place in all, and there is the same pressure ; consequently, on account of this equality, all those particles of the sixth kind, which in the beginning had been unequal, are rendered entirely equal, because of the continuity of the motion and fluxion. For unless there were equality in magnitude, there could not be equality in motion, and contrariwise. Therefore, because of the uniformity of motion, which always exists in an element or volume of particles, there also arises a perfect equality of magnitude. For if one particle be greater than others, it at once suffers pressure from the smaller surrounding particles. If one particle be less than others, it is not

touched by the surrounding particles. Consequently the greater become less by compression, and the less increase in size, as a result of a greater amount of attenuated matter flowing up. These things can be geometrically proved, as all the rest can ; but if we were to give ourselves up to proving each detail, this work would be increased enormously, and perhaps matters otherwise clear would become obscure.

91. PARTICLES OF THE SIXTH KIND ARE LARGER THAN THOSE OF THE THIRD KIND, BUT THEY MAY BE COMPRESSED UNTIL THEY ATTAIN A SIMILAR MAGNITUDE.

Particles of the sixth kind are bound to be larger, since their surfaces consist of greater and heavier particles. For the larger and heavier the superficial particles, the more extended can the surface become, especially if they have to be in equilibrium with lighter particles, although here equilibrium of weight cannot yet come into consideration ; for the same matter is enclosed in both. But that they can be compressed into small dimensions, and how such compression proceeds, shall be shown later.

92. THEIR MOTION IS ALSO SPIRAL, AND THEY HAVE TWO POLES, THROUGH WHICH THE ATTENUATED MATTER, OR MATTER OF THE SECOND KIND, FLOWS IN AND OUT.

It is clear from what has been said above, that the attenuated matter, or that of the second kind, gives rise to this particle, that is, that that attenuated matter will continue to move between the particles of the fifth kind, until it at length draws over to its own motion the particles of the fifth kind, and thus generates the particle referred to ; consequently this particle of the sixth kind holds attenuated matter enclosed equally as the particles of the third and fourth kinds. From this it results that it acts upon the surface of this particle in the same way as it acted upon particles of the third kind ; the originant cause is the same, and, therefore, the motion must be the same. The difference consists solely in the superficial particles, which are larger in the particles of the sixth kind than in those of the third kind. If, therefore,

there is the same motion in both, the effect will be the same, that is, the movement of the surface of this particle must be spiral. This motion has been amply described in the theory of the particle of the third kind; it would, therefore, be superfluous to repeat it. It is sufficient to remark that there is the same kind of motion in the surface of the sixth kind as in the surface of the third kind, and since the motion is the same, it follows also that this particle has poles; that the polar cones are formed in the same way as in the particles of the third kind, that is, the surface is able to penetrate through the walls of the cones as far as the centre, and that the attenuated matter possesses also the said cones; but it has a different motion in the cones from what it has in the cavity of the particle. But more may be seen on these things in numbers 35, 37, 38, 39, 43, 44 and in those that follow.

93. THE PARTICLE OF THE SIXTH KIND HAS MUCH IN COMMON
WITH THE PARTICLE OF THE THIRD KIND.

It would be tedious to explain all the qualities of this particle, since they have already been set forth in our theory of the particle of the third kind; for the motion is the same in both, the enclosed matter is the same, the motion in the surface is the same, the centripetal tendency is the same, and in both particles there is a kind of vortex. It would, therefore, be prolix to describe these qualities again. The reader may, therefore, be referred back to the theory of the particle of the third kind, and he will be able to apply to this particle, almost all that has been said about the former; this I here desire to indicate; both as to those things which have been stated regarding the movement of the surface and of the interior vortex, and those respecting its situation, and the forms and characters of the poles, etc.

94. IN THE INTERSTICES OF THESE PARTICLES OF THE SIXTH
KIND FLOW PARTICLES OF THE FOURTH KIND, TOGETHER
WITH ATTENUATED MATTER.

In order that the truth of this position may be evident, let us consider again the qualities and nature of particles of the fourth

kind. Particles of the fourth kind are those which have been compressed, and conceal within at their centre a kind of small globe, which floats in the midst and revolves along the equator. The particle of the fourth kind may be so small as to be numbered among the minutest particles. Let *A*, fig. 66, be a particle of the third kind, then by compression this may be so diminished by the surface matter passing over into a kind of central globe, that it may become like *B* or still smaller. For since the small central globe or particle of the fifth kind is so small as hardly to be considered, therefore, also, the particle of the fourth kind may become smaller and smaller, until it becomes a small globe. Consequently, the particle of the fifth kind is unique in magnitude, and may be rightly regarded as among the minutest particles.

Fig. 66.



That this kind of particle is fluent in the interstices of particles of the sixth kind is plain from the fact that particles of the fifth kind, or small central globes, came into existence as a result of compression, and, indeed, near the sun; particles of the fourth kind also arose by means of compression. It consequently follows that part of the particles of the fourth kind was in that encrusted volume, and part in the vicinity of it; for where there was the greatest motion there would be the greatest amount of compression, and the greatest amount of compression was near the sun or around its crust as previously pointed out. So the crust, having been urged into a gyration, acts on the neighbouring particles, and in consequence exerts pressure upon them, until they become particles of the fourth kind; also the nearer they were to the crust, the smaller were they, in consequence of the greater pressure exerted there.

It follows from these things that between the particles of the sixth kind there ought certainly to be particles of the fourth kind; both because they were at the same time in the crust or encrusted volume, and because they were in its vicinity, so that there could not be other particles to fill the vacant interstices. Minuteness also assists the matter; for there could be 100 or 1000

such particles between three or four particles of the sixth kind. Whence it is clear that there are no other particles that could occupy that position. This might be proved by many other similar arguments regarding the nature of that element, concerning which we shall speak below.

That there is also attenuated matter between, also follows as a consequence, because the particle of the sixth kind encloses attenuated matter, or that of the second kind, according to the previous propositions ; and it will be shown that this attenuated matter is able to flow in and out through the poles of that particle, in the same way as is the case in the particles of the third and fourth kinds. It has also been shown that the particle of the sixth kind arose from the motion of the said attenuated matter. Consequently, the attenuated matter is bound to be outside the particle either by rushing through its poles or arriving thither in another way. It is also clear that there is attenuated matter between these particles of the sixth kind ; for the particles of the fourth kind which occupy the interstitial spaces have a vortex consisting of particles of the second kind, or attenuated matter. Since, therefore, that vortex continually accompanies the particle or its surface, it therefore necessarily follows that in the interstices of the particle of the sixth kind there is certainly attenuated matter, which fills all those places which the particles of the sixth and fourth kinds are unable to do.

95. THE VORTICES CONSISTING OF ATTENUATED MATTER MAINTAIN THEMSELVES WITH DIFFICULTY IN THE POSITION AROUND THE PARTICLES OF THE FOURTH KIND, AND AROUND THOSE OF THE SIXTH KIND.

It has been shown in the preceding pages that the vortices consisting of attenuated matter were formed around the particle of the third kind, and the particle of the fourth kind. These vortices seem to be specially capable of persistence, as long as equal particles are in one volume ; so that if the volume consisted of no other particles but those of the fourth or third kinds, then the motion in all would be similar, and the vortices would be able

to be formed, and to persist when formed; there are the same motion and the same arrangement in all. But, in fact, since in one volume there are particles of different kinds, as here, particles of the fourth and sixth kinds, therefore the vortices which are outside the particle are hardly able to persist; there is a different motion, less or greater, in the particles of the sixth kind than in the interstitial particle, or that of the second kind. Also from the local motion 100 greater particles, or 1000 smaller or interstitial particles will certainly be moved; consequently, since the particles of the fourth kind are not here in their natural position and have similar ones all around them, they can with difficulty be kept in their natural position. For as a consequence, through the slightest motion of the larger particle, or that of the sixth kind, they are disturbed, and become unequal in the motion of their own vortex. Consequently, there can be no vortex which resembles the one previously mentioned, either around the particles of the fourth kind, or around those of the sixth kind. Indeed, the attenuated matter flows round, and takes a vortical form from the least superficial or spiral motion of the particles. But since that motion is disturbed every moment, it cannot be said that, around the surface, there is any true vortex, but only a small and very slight one, which continually undergoes disturbance.

As to the interior vortex, that is, the attenuated matter enclosed in the particles of the fourth and sixth kinds, it indeed is permanent, although it undergoes various perturbations, of which we shall treat below.

96. THE PARTICLE OF THE SIXTH KIND HAS ITS OWN POLES AND POLAR CONES THROUGH WHICH THE ATTENUATED MATTER FLOWS IN AND OUT, AS IS THE CASE WITH THE PARTICLE OF THE THIRD KIND.

This particle of the sixth kind came into existence in the same way as the particle of the third kind; that is, by fluxion of the attenuated matter. Consequently, when the said matter acts upon the surface of this particle, it is bound to urge its surface

into a spiral motion similar to, and homogeneous with the movement of the said attenuated matter ; in the same way as was previously stated concerning the origin of the particle of the third kind. Since, therefore, the attenuated matter is within and gives rise to motion, that surface motion is bound to be spiral, and form poles, an equator and an ecliptic ; for since the cause is the same, the same effect must follow. And when the poles are formed the attenuated matter will flow in and out through the polar cones in the same way as has been noted in reference to the particle of the third kind ; and it will have the same motion in these cones as in the cones of the particles of the third kind.

97. THE PARTICLES OF THE SIXTH KIND PRESERVE THEIR OWN POLAR SITUATION AND ARE MUTUALLY IN CONTACT IN THE CIRCLES PARALLEL TO THE ECLIPTIC ; BUT THE INTERSTITIAL PARTICLES, OR THOSE OF THE FOURTH KIND, CANNOT DO THIS IF THE LARGER PARTICLES OR THOSE OF THE SIXTH KIND ARE MOVED.

The particles of the sixth kind preserve their own polar situation ; from which it follows that the enclosed vortex or the enclosed attenuated matter drives the surface of that particle into a motion like its own, since its pole always has regard to the mundane pole. Consequently, they are bound to maintain the particle in that position, so that it may look to the mundane pole, or that the pole of the particle may correspond to the pole of the universe, just as is the case with the particle of the third kind, of which we have treated at sufficient length.

But as regards the interstitial particles or those of the fourth kind, these all look to the mundane pole, but because they flow between the larger particles, one of which can set moving one thousand interstitial particles, therefore, by the motion of one larger particle, one thousand, if not more, smaller ones are set in motion. Consequently, they are not able so exactly to preserve their position, because they revolve differently. But since that particle is impelled by the attenuated enclosed matter,

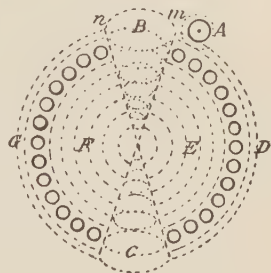
it is also immediately driven into that proper or natural position, in order, that is, that it may look to the pole, but after one or two preceding revolutions. In addition, the surrounding vortex is not so exact nor of such magnitude, as to be able continually to maintain those interstitial particles in their own polar situation, as in their natural position.

That the particles of the sixth kind are mutually in contact in the parallel circles of the ecliptic has been shown before in connection with the theory of the particle of the third kind; for the cause and reason are the same, consequently the effect is the same. Whence it would be superfluous to prove this point further. The paragraph itself may be consulted.

98. THE INTERSTITIAL PARTICLES, OR THOSE OF THE FOURTH KIND, CANNOT EASILY BE DEFLECTED TO THE POLES OF PARTICLES OF THE SIXTH KIND.

Let *GFED*, fig. 67, be a particle of the sixth kind, *A* a particle of the fourth kind. The enclosed attenuated matter *FE* sets up the spiral gyration as far as the centre of that particle; also the feeble vortex *DG* is urged into the same spiral motion. But the attenuated matter in the poles *BC* is driven by another motion; as previously shown, and as the figure represents it. Consequently, there is one motion of the attenuated matter in the particle as *FE* and another in the polar cones *BC*. The same is the case with the particle *A* of the fourth kind.

Fig. 67.



Its vortex also has a spiral motion, as is the case with the greater particle of the sixth kind. Consequently, that particle *A* can easily flow into the vortex of the greater particle *DG*; for its motion is homogeneous with and similar to it; nevertheless, it is the fluxion of the same figure, whence they can very well flow and be conjoined, especially when the vortices move into the same spire. But when the smaller particle, or that of the fourth kind, goes to the pole of

the larger particle *B*, immediately another and dissimilar motion meets it, this being both in the vortex of the larger particle and in the vortex of the smaller. Consequently, since the motions are different, as soon as they meet there is opposition and a conflict, as it were, between the attenuated matter in each. Therefore, the smaller particle *A* cannot approach nearer to the pole of the larger particle than the surface in which *B* moves. Then, on account of the opposition, either it is cast aside, or merely flows around the polar cone measuring out the circle *mn*. Nor would it seem able to approach nearer, unless the smaller particle were deprived of its vortex, and at the same time all the attenuated matter, which is enclosed in the particle of the fourth kind were absorbed, which, in this case, is plainly converted into a small globe of the fifth kind, and so recedes to the surface of a particle of the sixth kind, the particle of the fourth kind thus vanishing. But this cannot exist unless it is impelled into the gyration of the polar cone *B* by some driving force.

99. PARTICLES OF THE SIXTH KIND CANNOT BE CONJOINED
ROUND THE POLES.

It has been previously shown that particles of the third kind cannot be conjoined about the poles, and we have given the reason in our theory of that particle. And since the cause is the same, the motion is the same, and the attenuated matter enclosed in each is the same, therefore, the effect in regard to these particles is the same; it would therefore be superfluous to discuss this point further. The paragraph itself may be consulted.

100. THE VORTEX OF THE EARTH CONSISTS ESPECIALLY OF
PARTICLES OF THIS KIND.

In regard to particles of the first and second kinds a definite vortex may consist of these, since particles are formed of those from which a vortex can arise; consequently, since they cannot be designated particles, but a kind of points and seeds of particles, therefore, no vortical quality can be ascribed to them;

but they are merely called particles, in order that all the kinds may be more accurately distinguished.

In regard to particles of the third and fourth kinds, we consider that the larger vortex of the sun consists of these, in which the vortices of the planets and the earth flow and move.

The particles of the fifth kind, cannot be called vortical or elementary particles; for they have no other quality than that which constitutes the surface of the new or sixth kind of particles; for they possess no motion except that which is in the surface of each particle.

In regard to the particles of the sixth kind, in the interstices of which the particles of the fourth kind are in motion, we consider these to be those of which the vortex of the earth consists, as also the vortices of the rest of the planets. But the truth on this point can by no means be made clear to the reader, unless it is illustrated and proved by arguments drawn from special experiments. Therefore, as soon as we have stated the origin of such vortices, we shall set forth the nature of these particles; this could not be done before the vortex existed, and set up its own motion in that vortex. For unless they are in a certain vortex and are moved therein, no elementary quality can exist among them. An elementary quality exists as soon as the particles are urged into a vortical gyration; but not before that motion is the origin of the vortex, and the movement is according to the motion, situation and pressure of the particles.

101. THE VORTEX OF OUR EARTH BY A KIND OF REVOLUTION,
AND THEN BY THE CIRCLE OF A DEFINITE ECLIPTIC, GRADU-
ALLY WITHDREW FROM THE SUN TO ITS PRESENT DISTANCE.

The purpose of our principles is not indeed to show the origin of the larger bodies and of the planetary vortices, but only to describe the elementary particles and explain their properties. But because the procreation of these particles, and also their form and the properties which follow from it, cannot be made clear unless the history and origin of these vortices is dealt with according to our hypothesis, therefore, necessity requires that

the argument shall be continued and the hypothesis regarding the above subjoined ; but because it does not directly tend to the end which we have prepared, therefore it is our intention only briefly to explain these matters.

When, then, the mass or encrusted volume around the sun was disrupted, so that it could no longer be continuous with it, but be in a state of separation and free ; consequently, when it was of great size, and when that vast solar vortex in which the vortices of the planets and the earth flow, had been already formed, that is, when the particles or the entire vortical matter had been already urged into a regular motion, then, because this volume separated from that crust, by which the sun was surrounded, there could be no equilibrium among those particles near the sun ; nor could there be equilibrium with the motion of those particles, which were also far lighter. Therefore, because in that greater vortex of the sun, there was a kind of centrifugal action, that is, the heavier bodies tended from the centre towards the peripheries, it is not remarkable, that this mass, consisting of alien particles of the sixth kind from the sun, and from the lighter element, and at the same time of particles driven by swifter motion, consequently by a definite centrifugal law—concerning which we have previously treated, and must also treat below—withdrew itself from the sun, and betook itself toward the periphery, or to a certain distance from the sun ; and continued that course, or moved still further off, until it settled down, as it were, into a definite equilibrium among the heavier particles that were impelled by less motion—that is, by a general or vortical motion—thus a clearer conception is acquired.

It is evident from what has been previously said, that the sun, or the central ocean, consisting of attenuated matter, or of particles of the second kind, set up a kind of perpetual motion, and, at the same time, first impelled all the circumfluent matter into a kind of spiral gyration, but more remotely thence into a circle along the ecliptic, the reason for which has been stated above. Consequently, when the motion near the sun was extended thence toward the various peripheries, it follows, as

a consequence, that the motion of that matter was greatest about the sun, and less and less towards the peripheries, so that at a distance that vortical motion is diminished. This also is evident from the planets themselves; for the nearer they are to the sun, the more rapid is their journey round it; but the more distant they are, as in the case of Saturn, the slower is it, so that thirty of our earth-years are equal to only one of Saturn. Whence it is evident that the gyratory motion in the sun continually urges the surrounding matter into motion, and to a considerable distance therefrom, but that the motion decreases according to the distances.

When, therefore, such motion was begun and became perfectly regular, so that it might go on for ever, by God's will, then a vortex was formed. And in that vortex there are properties, of which we have in part spoken, and in part passed over. Nevertheless, one property or quality must here be stated, that is, that in such a vortex there must be a certain centrifugal tendency which causes heavier bodies to tend from the centre to the periphery.

This centrifugal tendency is chiefly the reason why the motion differs according to the distances from the sun. For a body flowing in such a vortex is forced by a greater motion towards that side which looks toward the sun than toward the opposite side. In addition to this a body moving in a vortex tends to take a direct path, and thus along the tangents of its own gyration; but on account of the general flow of the vortex, it is restrained from doing this; it is, however, gradually carried toward the tangents and removed from the sun to the periphery. These things, however, pertain to another subject. It is sufficient for our purpose that in this solar vortex there is a some kind of centrifugal tendency.

Since, then, there is a definite centrifugal tendency in that large solar vortex, it follows also, as a consequence, that in that vortex particles from the sun are forced toward the surface, that is, the particles next the sun (that is, the motion has now become regular; in the beginning it was the contrary) are less

compressed than the particles which are removed to a distance therefrom. Therefore, because of the centrifugal tendency, the particles that suffer greater compression are more remote from the sun than those which are near it, consequently there is a difference in those particles in the large solar vortex which are near the sun. There are particles of the third kind that are more remote; there are particles of the fourth kind; and these are greater and less according to the pressure and their distance from their sun.

Since, then, particles of the fourth kind can be of very diverse magnitudes, as *A*, *B*, *C*, in fig. 68, therefore, those which are nearer the sun are like *A*, those at a distance like *B*, and the most distant like *C*; and finally, that vortex ends when the particles are so small as a result of compression that they escape, so as almost to lose their proper or spiral motion, and are almost changed into a kind of small globe or particle of the fifth kind.



Since, therefore, the said particles are dissimilar in expansion and magnitude, and this difference arises from the differences in their distances, it thence follows that the volume of particles *A* is much lighter than the volume of particles *B*, and so throughout; and that the volume of particles *C* is much heavier than the volume of the particles *B* and *A*; whence the difference in weight is proportionate to the distances from the sun; and, consequently, if some heavy body is carried by centrifugal force from the sun to a certain periphery in the vortex, it may at length reach a certain periphery, where there is equilibrium. In that periphery the heavy body would have a stable position; for if it went farther, it would be carried outside its position of equilibrium, and back again to the periphery where the particles or volumes are in a state of equilibrium.

Since, therefore, the volume of encrusting particles consists not only of larger, but also of heavier particles, it, consequently, cannot possibly exist around the sun, because it would be carried by centrifugal force to some periphery more remote.

Hence, since the ordinary motion of the vortex is spiral, and has a kind of gyration along the ecliptic, this volume cannot be carried in a right line and perpendicularly therefrom, and thus come to a definite distance from the sun, being compelled to follow the common motion of the vortex, and for a long time to be carried round the sun, and to be gradually removed by that circular motion to a greater distance.

For example, if, in fig. 69, *A* be the sun, then the volume separated from the crust by a definite spiral circle must be carried thence, until at length it reaches that distance *B* where is the equilibrium of the volumes, so that the volume of such particles in the large vortex equals the weight of the volume in this vortex, or the weight of the vortex.

Fig. 69.



This follows from the nature of the vortex, and from the centrifugal force which causes a difference in the different peripheries; consequently also at a certain periphery the volume is at rest and finds its equilibrium. This cannot be the case at the same moment, but gradually, and after several revolutions round the sun, or its own centre. For this reason it can be said, that many years were completed, before the vast volume or vortex of our earth, of which we have just now treated, reached its limiting boundary. Something also requires to be said about the vortices of the rest of the planets. But our purpose being to examine the variety of the particles surrounding our earth, and, consequently, to search out their natural and elementary qualities, therefore we leave the rest as being quite unknown and somewhat too recondite for us.

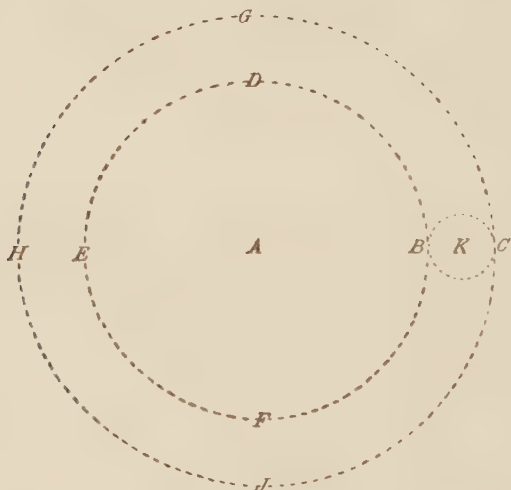
102. THIS VOLUME RECEDING GRADUALLY FROM THE SUN HAS A SPIRAL MOTION IN ITS FARTHEST PART, AND, CONSEQUENTLY, FORMS POLES.

In the preceding paragraph we have treated of the course of the motion of this volume from the sun and its ultimate gyratory movement, which gradually ceased, and so it acquired on its

path a double motion, one an orbital motion, and the other at right angles to the sun, whence a double motion results ; for this reason it receded spirally from the sun according to the statement in the preceding paragraph. It is evident from these things that that volume moves round the sun, and, indeed, by a gyre along the ecliptic. In the previous pages it has been sufficiently shown that the entire motion of the vortex proceeds along the ecliptic, which the volume sent into that vortex also follows.

We have, therefore, treated of the annual motion of that volume, or of its flow around the sun. Here we must deal with the motion of the volume itself, which gives rise to the motion of the moon and also of our earth, along the equatorial circle,

Fig. 70.



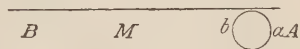
and, consequently, imparts the nature of a vortex. For unless such a motion exists among the particles, the designation "volume" is correct ; but directly this volume revolves, or even moves of its own accord, it must be designated a vortex.

As to the motion, then, if this vortex is in its extreme part or on the surface, it would seem to be spiral ; but yet the spirals proceed along the circle of the ecliptic, so that all this motion takes place along the ecliptic of the large vortex.

As to the reason of this, consider fig. 70. Let *A*, the centre,

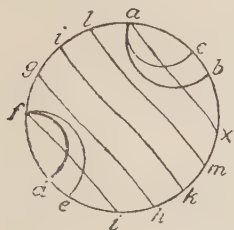
be the source of motion or the sun. Let K be the earth or that vortex in which the earth is enclosed; let the annual motion of the vortex be between the circles, for example at BC, DG, EH, FJ . But the motion of the large vortex is more rapid at B , since it is nearer to the sun, and slower at C , since it is further from the sun. Since, therefore, the motion is twofold, being different on one side from what it is on another, therefore the more rapid motion has the greater force and has a stronger action at B than at C . It, therefore, follows that there is no equilibrium of motion, it being unequal at every point; consequently, it is bound to take on a revolution, the motion being more rapid at B than at C . And since each motion acts according to its own force, on account of the inequality it acts more strongly at B than at C , whence it is bound to revolve in its own path around the sun, or annually, and set up a definite motion in itself. This can be proved experimentally. Let, in fig. 71, a

Fig. 71.



sphere A revolve by aid of the arm BM . If the sphere A can also turn on its axis, then if this arm, at whose extremity the sphere is capable of revolving, be turned either in water or in air, then that sphere will revolve round its axis; and the more rapidly the arm is revolved the more rapid the motion. The reason of this is, that the resistance of the water or air is greater at a than at b , consequently, it tends to revolve in that direction; but if the resistance were greater at b than at a , the motion of revolution would tend in

Fig. 72.



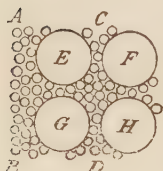
the other direction. It is the inequality of motion or resistance that causes the revolution. The same reason applies to the motion of the vortex of our earths.

This revolution can be no other than that which is seen in the flow of the large vortex, that is, along the ecliptic. For the circle of fluent matter in the large vortex is the ecliptic. Consequently, if it acts in a similar manner at x , fig. 72, as $mkhi$ towards $alig$, the whole revolution is bound

to be along the ecliptic; but because that surrounding matter acts not only in mk , but also in the smaller circles xh —and there is a greater diversity of motion around $mkig$, than round xh ; therefore, there is a spiral action, so that the pole of the ecliptic cd changes its position and its own movement round the mundane pole. This is the reason why the lunar ecliptic changes its nodes with the earth's ecliptic or with the equator.

That the fluent matter in the large vortex has the power to cause this whole vortex to revolve is evident from this, that the

Fig. 73.



material of the large vortex consists of small particles of the fourth kind, as AB in fig. 73.

The matter of the earth's vortex consists in part of particles of the sixth kind, E, F, G, H , and in part of those of the fourth kind, which float about as enclosed particles. Consequently, the fluent matter CD cannot be otherwise con-

sidered than as contiguous to the matter of the large vortex, and, consequently, more easily communicates its own motion. For, since all the particles act at the same time by their own motion, and, indeed, 100 or 1000 particles of the fourth kind upon one particle of the sixth kind, therefore, they must absolutely obey this motion; and because the torrent or stream acts more vehemently on one part than on another, it, consequently, sets up a revolution in the way previously shown.

In addition to this there is no motion of revolution near the poles of the equator, and the poles of the ecliptic; for there is not much difference between one side and the other, consequently, there is not much difference between the motions; but they are almost coincident here. Hence no motion of revolution can be set up there; but the force is very great round the larger circle, or the ecliptic, whence the poles are formed.

103. THE MOTION ROUND THE CENTRE, OR THE MOTION OF EACH CENTRAL GLOBE TAKES PLACE ALONG THE EQUATOR.

We have explained the reason of this in the previous pages when treating of the particle of the fourth kind, and the small

globe enclosed in it. For the matter flows spirally through the polar cones; and this spiral action terminates near the centre in a circle perpendicular to the polar cone, whence the revolution at that place is bound to be near the equator.

We also gave another reason, namely, that the spiral path in the vortex naturally and geometrically ends in a regular motion; that is, in a motion along the equator. It consequently follows, that there is another pole of the ecliptic, if that motion be considered which is near the surface, and another, if that motion be considered which is nearer the centre. For the nearer the motion of the vortex approaches the centre, the more does the pole of the ecliptic approach the mundane pole; and, at length near the centre, or near the central globe, the pole of the ecliptic coincides with the mundane pole. Concerning these things, see what has previously been said about the particle of the fourth kind, and about its central globe.

104. MOTION IN THE BEGINNING OF CREATION WAS MORE RAPID THAN AFTERWARDS, AND, CONSEQUENTLY, THE YEARS AND DAYS PASSED MORE QUICKLY; BUT THE MOTION OF THE TERRESTRIAL VORTEX WAS ALREADY DEFINITE AND FIXED, SO THAT IT COULD ONLY BE CHANGED BY THE WILL OF GOD.

That motion in the beginning of creation was altogether more rapid is clear from this, that at that time the extent of the volume stretching from the sun to the periphery, which now exists, gradually decreased. And, consequently, it was nearer to the sun, but by gyrations and numerous revolutions it at length reached a certain circle in the vortex where it came into a position of stability by its own weight. When, therefore, this volume had measured out that space, or described these revolutions, and was nearer the sun, its annual revolution round the sun must certainly have taken place in less time; for the circle was less and the motion more rapid; consequently in the beginning the solar year was completed in a few days, afterwards it took weeks, and, at length, months.

But as to the diurnal revolution itself of the earth, that also seems to have been more rapid ; for the motion of the large vortex near the sun was more rapid than at a distance therefrom, according to what has been proved in the preceding pages. Consequently also the revolution of the volume, or of this vortex, must have been more rapid. When the motion is stronger, then also a stronger effect follows ; therefore that motion of revolution seems to have been very rapid. And since, in the extreme limit of the vortex, it was very rapid, it necessarily follows that the gyrations as far as the central globe were very rapid, and similar to the motion thereof. According to our theory, therefore, night and day could be completed within the time that corresponds to our hours, that is, three or four revolutions would have been completed within twenty-four hours of our time, and, nevertheless, three hundred and sixty, or three hundred and sixty-five, days might have been passed through within the space of a year.

How many years elapsed before the vortex of our earth attained the orbit in which it now moves cannot indeed be exactly calculated, nevertheless I maintain that it would not be so difficult for mathematics to deal with such matters ; certainly a great length of time must necessarily have elapsed.

But when it had now reached the circle, in which the vortex with its surrounding matter maintains its equilibrium, there would seem to have been no further effort to reach a more distant periphery or an orbit more distant from the sun ; but there it lay as if in its own bosom, and was quietly carried round by the stream of the primary vortex, and with this motion it completes its years ; and by the motion of its own vortex its revolutions, or its days and nights, are described along the equator. Nor would it appear that the earth's vortex could approach nearer, or recede farther from the sun, but that it would continue to move in its own orbit for ever, unless, God willing, the motion of the large vortex underwent a change through some other large vortex coming into existence in its

vicinity, or its circles suffering perturbation from the rushing of some comet into this large vortex.

That in the beginning of creation the years were not so long as they are to-day, or that the yearly course of the earth described a smaller circle of gyration around the sun, also that its motion was more rapid, so that the year, although it had as many days, nevertheless was only $\frac{1}{10}$, $\frac{1}{9}$, $\frac{1}{8}$, $\frac{1}{7}$, $\frac{1}{6}$, $\frac{1}{5}$, $\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$, $\frac{3}{4}$ of the length of the year at the present time; and again that the diurnal revolutions of our earth were performed within much less time than now—all this would appear not only to be consistent with our theory, but also with the history of ancient times.

The Sacred Scripture makes mention of paradise and all the delights of a garden, this garden, however, does not appear to have flourished for long. It would not seem unreasonable to think of a perpetual garden which clothed the whole earth, or to suppose that the whole surface of the earth was covered with delightful little gardens, when the yearly journeys of the earth were accomplished in a sufficiently short space of time. Thus the times of the year would follow one another with a brief interval, autumn immediately followed summer; winter the autumn, and spring winter. Hence the sun's heat in summer was tempered and reduced immediately by autumn and winter. The cold of winter could not last long, for it was at once followed by the temperate periods of spring and summer. In addition to this, the diurnal revolutions also rendered the temperature equable. The cold of night was nullified by the heat of the day, or mid-day, and contrariwise, the heat could not attain any high temperature; for as soon as the cold began to increase through the absence of the sun, the morning, and the rising of the sun followed; nor was sufficient time left for the increase of the cold at night or for the mid-day's heat; for changes took place swiftly and alternately, and within the briefest periods. Consequently, it follows from our theory that there must have been certain parts at that time that resembled a garden.

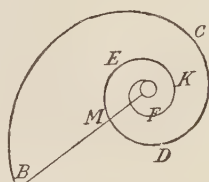
In addition to this, there succeeded the golden age; this

was followed by the silver age, and at length by the ages of iron and clay, as the poets sing, a sign that former ages bore some resemblance to a pastime and the noblest metal, and that nature herself, most pleasant and delightful, wore a very joyous countenance; and that there was nothing anywhere throughout the whole world that did not flourish and enjoy its youthful prime. But as time passed those joys and sports of youthful nature put on a mournful aspect, that is, our earth gradually withdrew to a greater distance from the sun, and the annual and daily revolutions, consequently, became more protracted. As a result of this also the intervals of winter and summer, of day and night, increased; from which it follows, that in winter the cold became keener, and in summer the heat more intense than formerly; and, consequently, as nature increased in age, and grew old as it were, she became less pliable, there being, as in the case of men, less joyousness.

From the Sacred Scripture it is clear that in the beginning animals were created, and that fishes and creeping things came into existence; but all these things came forth from the earth itself and the ground. For the Scripture testifies that the Almighty commanded that the earth should bring forth animals, and the waters fish of all kinds, and that man himself should be formed from the soil. Also at that time the seeds of trees and flowers were scattered over the surface of the earth, and many other things which indicate that the state of nature on our planet was quite different from what it is to-day. That is, nothing on the earth became torpid from long continued heat or cold; but there was, as it were, a perpetual spring, and a medium temperature between heat and cold. For unless the climatic conditions as to temperature had differed greatly from those of to-day, I hardly see how, in obedience to Divine command, animals and fish of all kinds could have been produced, with the earth and the sun as the means. When Omnipotent God commands He supplies the means, and imparts strength to the earth and a procreative virtue, which it is likely to have had since it was at a middle distance from the sun.

The same thing can be proved from the long life of the patriarchs. This may be partly attributed to the simplicity of their food, to their unsophisticated habits of life, and the consequent peaceful state of their minds; and partly to the extremely short length of the years. For in this way the patriarchs could pass a hundred years or what is the same, they saw the return of a hundred winters or summers, where we count only ten. Yet the period of a hundred years with them equalled only ten of our years, as follows from what has been previously stated. But the years returning so quickly seemed shorter, so that afterwards the posterity of Noah scarcely reached a hundred or a hundred and twenty years. This follows from the fact that the vortex of the earth departed from the sun by a definite spiral gyration. And, in fact, in the beginning it described only small gyrations, nor did it recede a great distance from the sun. But when it had proceeded a distance therefrom, and the effort to reach the periphery was increased as the square of the times, then the earth was able to advance within a few years, or at least, within fifty or eighty from *M* to *C*, fig. 74, and arrive at the orbit in which it now moves to-day. Consequently, the ages of men, in so short a space of time, appeared to diminish, say from seven hundred or nine hundred to one hundred or one hundred and twenty years. The reason of this we have stated in the previous pages.

Fig. 74.



Much other additional testimony could be adduced which would seem to confirm the theory of this paragraph, but since what we have brought forward already is sufficient, it will be enough to quote Ovid on primeval ages.

The golden age was first ; when man, yet new,
No rule but uncorrupted reason knew :

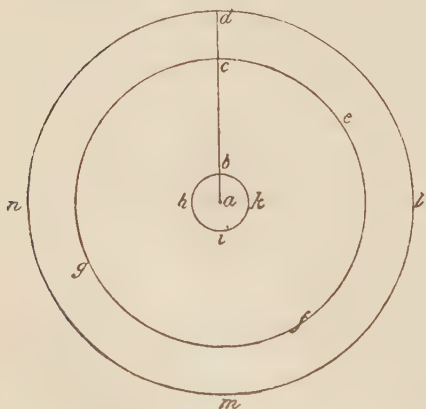
The flowers unsown, in fields and meadows reigned :
And western winds immortal spring maintained.
In following years the bearded corn ensued,
From earth unasked, nor was the earth renewed.

From veins of vallies, milk and nectar broke ;
 And honey sweating through the pores of oak.
 But when good Saturn, banished from above,
 Was driven to Hell, the world was under Jove.
 Succeeding times a silver age beheld,
 Excelling brass, but more excelled by gold.
 Then summer, autumn, winter did appear :
 And spring was but a season of the year.¹

105. THE MOTION IS MORE RAPID THE FURTHER IT IS REMOVED FROM THE CENTRE OR FROM THE EARTH ; BUT, NEVERTHELESS, ONE REVOLUTION CAN BE DESCRIBED ABOUT THE SURFACE OF THE VORTEX, WHILE SEVERAL MAY BE DESCRIBED IN THE SAME TIME ABOUT THE CENTRE.

The gyration of the vortex must not be understood as being so swift as to revolve more often, or as many times in a day as the earth itself along the equator. There is no doubt that the movement of the vortex about its surface is more rapid than nearer to the centre. For the gyration commences in the surface, as we have shown before. For it proceeds from

Fig. 75.



that source toward the centre ; therefore it is diminished, or the velocity becomes slower the more distant it is from its source, or from the surface. Consequently, the velocity of our earth is much less than the velocity about the surface. But the gyres or circles, although the motion is swifter, can nevertheless be described in the same

time ; but the larger the circle the more time will be consumed in describing it. For example, in fig. 75, let

¹ Ovid, *Metamorphoses*, bk. i. 89-118, translated by John Dryden.

ndlm be the circle, which the surface of the vortex describes with the given velocity. The circle *cefg* is smaller, but its velocity is greater; *bkih*, or the earth, is a still smaller circle, which is described with less velocity; consequently, the smallest circle *bkih* is described ten times while the circle *cefg* is being described once or twice, and yet the velocity in the circle *cefg* is greater. The circle is larger, consequently, although the velocity in it is greater than in the small one, *bkih*, still the circumference is described only once with greater velocity, although the velocity in the smaller is twenty or thirty times less. For example, let the diameter of the smaller circle *ab* be 1; the diameter of the larger circle *ac* 5; then, if the velocities were equal, the smaller circle *bkih* would revolve five times while the larger one *cefg* would describe only one revolution. But if the smaller circle revolved three times, while the larger one *cefg* revolved once only, then the velocity of the revolution of the greater circle would be greater, although it revolved once only; and the velocity of the smaller circle would be less, although it performed a revolution in the same time.

It is for the same reason that the moon in the earth's vortex revolves in its orbit in twenty-eight days, although the earth makes one revolution in twenty-four hours. For the diameter of the circle which the moon describes is so large that the motion of the moon or the motion of that circle is more rapid than the motion of the earth in its revolution around its axis. The same is the case with the rest of the circles in the same vortex; the farther they are removed from the terrestrial globe, the more rapid is their movement; and the reverse is also the case. But that it takes several days to describe the circles, when the earth performs its revolution in one day, results from the amplitude, or the greater diameter of the circles; and the difference of motion depends on the difference in the size of the circles.

106. WITH A GIVEN MOTION FROM THE PERIPHERY TO THE CENTRE, A KIND OF VORTEX ARISES, THE FLUX OF WHOSE PARTICLES TENDS TO THE CENTRE, AND CONSEQUENTLY A CENTRIPETAL TENDENCY ARISES IN OUR VORTEX.

It has been stated that in the vast solar vortex there is a centrifugal tendency, that is from the sun to the circumference ; for the motion near the sun is very great ; but less in the circumference ; consequently, the heavier parts from their greater motion tend to the place of slower motion. The reason for this has been stated in the previous pages, and requires to be further dealt with.

1. Since the motion undergoes a diminution from the centre toward the circumference, therefore any body from that part where there is the greater motion, is impelled with greater force than if it came from another direction, where the motion is less ; consequently, the body, impelled by greater force, is driven into the circle where the motion is less. This agrees with geometry and experiment.

2. Another reason is, that a body in such a vortex is compelled to follow its general movement, and to describe revolutions or circumferences in accordance with it ; consequently, when this body is carried by the general flow of the vortex it is bound to have a tendency to rush off at a tangent, but every instant, when it strives to do this, it is driven from a part where the motion is greater toward the centre or the surface, and, consequently, in that general motion of the vortex it descends or ascends in agreement with the centrifugal or centripetal tendency.

3. Since the particles in such a vortex are mutually incumbent upon one another, so that a higher particle rests on a lower, therefore, a difference in the particles arises in each circle. A heavy volume cannot subsist in a light volume unless it is impelled, by causes previously mentioned, either to the centre or from the centre to the circumference ; consequently, every instant the state of the particles is changed ; and this is different in

every circle, whence at length it passes from the lighter to the heavier element or volume, until finally it falls into that element or circle whose volume equals the weight of the volume of the body. But more will be said on these points in the following pages.

107. THE PARTICLES CONTAINED IN THIS VORTEX, IN CONSEQUENCE OF THIS MOTION AND CENTRIPETAL TENDENCY PUT ON VARIOUS ELEMENTARY PROPERTIES.

The volume of such particles could, of themselves, have no properties unless it were continually impelled under the influence of some kind of motion and gyration. Therefore, the volume of our vortex, before it was impelled to take a spiral motion, could have no elementary properties, before it was driven into gyration; then it first put on a nature which we call elementary. For if a volume without such gyration and motion be thought of, then, nothing can enter into consideration but the central motion of some particle. Also, as no particle rests on another, and there is no regular arrangement among the particles, the distance between the particles must be unequal; and clearly nothing can take place there that can come within the category of elementary particles. But immediately the matter of this volume is impelled to gyrate, and the resulting gyrations begin in the surface, and continue toward the centre, then the elementary quality among them is made manifest; then the volumes have to be considered according to their amplitude and compression. There exists, too, a kind of centripetal tendency of the heavier parts: and innumerable other things take place which must be separately dealt with. Therefore we must conclude, that this circular motion is the principal cause of phenomena and of elementary properties, because these had no previous existence.

But to determine the moment and time when this vortical nature came into existence and first gave rise to elementary properties, we must suppose that they did not exist when this

volume constituted one part of the crust around the sun, but that as soon as this volume broke away from the crust, was separated from it and driven from the centre, it then immediately entered on its path and attained to a certain distance from the sun. Then from the motion of the large vortex, according to what has been previously said, the volume was immediately urged into a gyration, and the earth into the motion causing night and day and also the yearly motion. And when this motion reached the earth, so that it also was caused to revolve, there the said elementary qualities seem to have first begun, that is, elementary nature came into existence together with day and night before the changes of day and night supervened. Nor does any elementary nature, such as we know it to-day, seem to have come into existence; consequently it seems to have begun at the same time as the motion of the earth.

108. THE PARTICLES OF THE SIXTH KIND RESTED UPON ONE ANOTHER IN THE VORTEX, AND GAVE RISE TO A GRADUALLY INCREASING PRESSURE TOWARD THE CENTRE.

It has been previously stated that this vortex of the earth consisted of particles of the sixth kind, and of interstitial particles of the fourth kind.

Now, with regard to particles of the sixth kind, these particles are peculiar to this vortex, or its common material. The interstitial particles of the fourth kind are also in common with the particles of the large vortex, in that circle. These particles of the sixth kind move vortically from the periphery to the centre, and, since a definite centripetal tendency arises from this motion, it therefore follows that one such particle rests on another, from the surface to the centre, and thus is the cause of the incumbent pressure which gradually increases from the surface toward the centre.

We shall treat of this pressure below when we deal with the birth of particles of the seventh and eighth kinds.

109. THE RADII, WHICH ARE SAID TO BE PERPENDICULAR IN THIS VORTEX, DO NOT PROCEED IN A STRAIGHT LINE, BUT RUN IN A CURVE.

Let us imagine a stone or other heavy body gliding from the extreme surface of this vortex to the earth as far as its centre, I say that, then not a right line, but a curve would be described, or that a perpendicular line is not straight, but curved. The said stone undoubtedly follows in its fall the common motion of the vortex, and so when a space of time intervenes it is carried somewhat along the horizon; and since the earth moves also at the same moment according to the same gyration, therefore, it always tends to the same place, and thus the line is said to be perpendicular. But because it is at the same time carried in a parallel horizontal circle, it departs from the true line, and therefore it glides down with a twofold motion, one along a horizontal line, and another along a line leading to the centre; consequently a curve is bound to be described.

If one also considers that a circle far from the centre has not the same motion as one near to it, then, if a stone falls from the surface of the vortex to the centre, the line will appear to be curved; and, therefore, a line which is said to be perpendicular, is actually not a straight line but a curve; in comparison, however, with the general motion, which otherwise must be regarded as rest, it may be called a line.

110. THE GYRATION OF THE TERRESTRIAL VORTEX MAY BE MORE TRULY CALLED REST THAN MOTION.

The elementary particles themselves which are the cause of the centripetal tendency of all things are carried round in a large circle; and the surface of the earth and the inhabitants who live on it are not moved independently by that surface, but together with it; consequently the surface of the earth cannot be said to move, but, rather, to follow the general motion, and to be borne, as it were, at rest in the bosom of something; like any kind of body in the air or

in a vortex; which shows that this general motion cannot be said to be motion, but may be spoken of as quiescence. It may be compared to an infant in its mother's womb, which does not move, but follows, as it were, the motion of its mother. So also a sailor on board a ship which is driven along by its sails, may be at rest on a vessel, although, in relation to the sea and the land he is moving. Similarly with a drop or volume of water in some body or vessel that is in a state of motion. For when a body follows the volume of an element, it is in a state of rest in the element; but the element itself is the subject of motion. For the same reason an element is in a state of motion in its own vortex, and the earth similarly. But whatever is the subject of the same, motion may be said to be at rest in the body or element, but not to be in motion. The motion is relative to the neighbouring parts, in reference to which the motion may be said to be localised. But when the neighbouring parts become the subject of motion, then everything is in a state of motion, but whatever is enclosed in the body that is moved, is at rest. Therefore the vortex in respect to the bodies which are outside the vortex is the subject of motion; as for example the sun, the neighbouring stars, etc., in relation to the matter which flows extraneous to them. But whatever in that vortex obeys the said motion cannot be said to be moved in relation to any matter whatever contained in the vortex. The same applies to this body, if anything is enclosed in it, and so generally.

111. MATTER CONSISTING OF PARTICLES OF THE SIXTH AND
FOURTH KIND FLOWS IN THROUGH THE POLES, BY WHICH
THE LACK OF THAT MATTER AROUND THE EARTH IS
SUPPLIED.

There is another motion of the particles in the polar cones, as was previously shown. But as to the nature of this matter, it is evident that it is the same as that which is in the surface, or the outermost part of this vortex; consequently, the same matter flows in through the poles, as elsewhere flows in the

outermost part of the vortex, since that matter is less compressed; therefore it enters continuously in a gyratory manner. And if there is any lack of that matter around the earth, it is supplied by the new matter which flows in through the poles. If the vortex suffers compression from other vortices or from other causes, then more and more of that matter flows in through the poles; and when it reaches the central circle, it undergoes compression, and, consequently, the volume or extent of the vortex may suffer diminution. Whether anything enters through the poles which finds its way across from the vortices of other planets, is not the point under consideration, nor can it be definitely determined.

112. IN THE BEGINNING OF CREATION THE PRESSURE AROUND THE EQUATOR WAS FAR GREATER THAN AT THE PRESENT DAY, AND CONSEQUENTLY WATER FROM THE EARTH'S EQUATOR WAS CARRIED TO THE POLES, WHERE IT STOOD AT A GREATER HEIGHT AT THAT PERIOD.

It appears from considerable evidence that the ocean in primeval times was deeper than at present. Witness the many mountain peaks which seem to have been entirely submerged in which vestiges of some ocean can be discerned. [Fossil] fish in mountain caverns and also on their very summits testify to the fact. Shells bear witness to the same fact, and also various kinds of *testudo* which lie at great heights on the very tops of mountains in great abundance. Thick strata of *testudo* can be seen near Mount Bohusia lying at a height of more than a thousand yards from the surface of the ocean, as the dwellers there have burnt lime from them for a hundred years, and there are sufficient to last a hundred years more. The whole of our earth, which has an uneven surface, is here and there strewn with enormous rocks, here elevated into hills, there again marked by rocky peaks, here by depressions; and there are a thousand other indications all tending to the same end, proving that our earth was once under the sea, or that the depth of the ocean was formerly greater than it is to-day.

The cause of this can be seen below, where the origin of salts and metals is treated of. For when water passes into salt and rocky matter its height is quite diminished. But our purpose in this place is to prove that the height of the ocean was greater toward the poles in former times than to-day. The reason of this is clear. When the vortex of our earth receded from the sun to the orbit in which it now revolves, on which journey it probably spent a thousand years, then, as a result of a greater and more intense motion of the solar vortex, its motion gradually became less and less. The more rapid motion of the large vortex was near the sun ; and, consequently, the action upon the equator of the earth's vortex was greater. For the greater the motion, the greater the action ; and, consequently, the greater was the pressure upon the said vortex of the earth. For before it chose to follow the general motion of the large vortex in that intenser motion there must have been resistance ; and if the resistance and motion were greater, it follows therefore that the pressure was greater. The greatest pressure was upon the vortex of the earth near the equator or the ecliptic, where the circle is the largest. Therefore, on account of that pressure upon the larger circle, there was also pressure upon the ocean or the water with which the earth was surrounded ; and, consequently, the ocean being subject to pressure more about the ecliptic or the equator than about the poles, the water toward the poles then stood at a greater height than to-day. But at the present time, since the motion or pressure is not so great, the water has gradually receded from the poles^e and seems to have betaken itself towards the equator.

113. PARTICLES OF THE FOURTH KIND, WHICH IN THE VORTEX OF THE EARTH FLOW BETWEEN THE PARTICLES OF THE SIXTH KIND, ALSO SUFFER COMPRESSION IN THE VORTEX THROUGH THE CENTRIPETAL TENDENCY, AS ALSO PARTICLES OF THE SIXTH KIND.

In the vortex of the earth, particles of two kinds suffer compression ; for each kind of particle takes on the nature of a

vortex by means of motion. Particles of the fourth kind are indeed so separated from those of the sixth kind, which are outside the tellurian vortex, that they flow between particles of the sixth kind and there pursue their motion. Hence when particles of the fourth kind are moved by means of gyrations, which are continued from the surface towards the centre, then a kind of elementary nature arises among them ; also between particles of the sixth kind. As a consequence, from the surface as far as to the centre they are gradually compressed according to the ratio of the distance, just as the particles of the sixth kind ; but yet the pressure of these particles is not derived from particles of the fourth kind nor contrariwise, but each kind derives its elementary quality from the vortical motion of which we have previously spoken.

114. THE VIBRATION PROCEEDS VERY RAPIDLY IN SURFACES OF THE THIRD, FOURTH, AND SIXTH KIND OF PARTICLES, BUT WITH A DIFFERENCE OF RAPIDITY IN EACH CLASS OF THESE PARTICLES.

The theory of vibration in particles is of great moment, for it explains the unknown quality both of light and other phenomena ; consequently, it is of great consequence to investigate its nature more deeply.

As to vibration in particles, it serves to show what is the nature of vibration in any particle ; since the particles of the third, fourth, and sixth kind are very much alike, but differ only in magnitude, therefore I desire to explain the nature of vibration in all these cases.

By vibration is meant motion on the surface of a particle by which the surface is simply moved or vibrates without the particle itself being moved as a whole. For if the particle itself were carried from place to place, there would be no vibration ; nor if the centre of the particle were moved reciprocally with the surface, but only the surface vibrated, the centre of the particle being at rest. Just as if you were to strike a distended bladder, its surface would be reciprocally moved, the centre

of the bladder remaining quiescent. I therefore designate vibration, motion in a struck surface only.

As to these particles of the third, fourth, and sixth kinds they are well adapted to receive vibration in the surface. For a particle consists only of a very thin and mobile surface, and that surface has attenuated material enclosed within it, which like a vortex tends to the centre and distends the surface of the particle with perfect uniformity. Therefore particles of the third, fourth, and sixth kind are highly perfect mechanisms for the reception of vibratory motion, by which nature affords such a variety of phenomena to our eyes and senses. In a word, the said particles are, as it were, fashioned and born for taking up that extremely rapid motion, and extending it throughout

Fig. 76.



their entire surface. Let BCA be the surface of a particle of the third, fourth, or sixth kind. If this surface be struck at a very small point, so that one part vibrates, then that vibration will immediately run round the particle and, indeed, throughout the whole surface; nor will it cease

before it has returned to its former state. This minute point on the surface traverses the whole and every part of it. Consequently, if a blow be struck at one point, that percussion or vibration will extend to all points, or to the whole surface. For it extends in an instant to the entire surface and produces everywhere the same effect as if that surface were vibrating although there is only one point.

Nothing prevents the point running throughout the whole surface under the influence of this vibration. The attenuated matter which is enclosed can offer no impediment; for it very easily yields, and gradually gives way by its own expansion, and diminishes the vibration that has begun. Nor does the surrounding matter offer an impediment, as is also evident from that attenuated matter, which does not react and fight against the given motion—consequently, any point that has taken up the vibration can run in a moment throughout the whole surface. Whether one minute part of the surface can

communicate its own vibration to another minute part or from a neighbouring point in the same surface I hardly know.

Now no definite reason can be given for the vibration, unless it be found in the element itself, which possesses elementary properties; but, in fact, in the surface of such a particle no elementary property exists, so that one particle rests on another, and communicates its motion to a neighbouring one, and then the motion in the neighbourhood is dissipated. But we must rather consider that the particle which receives the vibration, maintains it throughout its entire revolution; the same is the case if several points of the surface take up the vibration at the same time; but of this we must treat below.

As the mode of vibration has been explained, and its nature in the surface of the particles, that is, that the points in the surface run over the surface like a wave, the particle being at the centre at rest, we must now explain the difference existing between the vibration in particles of the third, fourth, and sixth kinds.

In a particle of the third kind the vibration is very rapid; for there is nothing to impede it. The surface consists of points of extreme lightness; the interior parts consist of attenuated matter, which matter facilitates rather than impedes undulatory motion; the exterior parts consist of attenuated matter; and there is nothing to offer any obstruction but the very rapidly vibrating point which runs over the entire surface and indicates that almost the whole of it is in a state of vibration.

In particles of the fourth kind the vibration is still more rapid, and within the same instant is able to run throughout the entire surface; for the particle of the fourth kind is less than the particle of the third kind, and the motion of the surface more rapid in regard to the succession of the revolutions. And the matter forming the surface in particles of the fourth kind is the same as that in particles of the third kind. Hence the vibration runs more quickly over the surface of particles of the fourth kind than over the surface of particles of the third kind. And since particles of the fourth kind are very different in

magnitude from the former, therefore the less the particle of this kind or the more it is compressed—it is not, however, so compressed as all to pass into a small globe—the more rapid the vibratory motion; as follows from what has been previously stated.

But the vibration in particles of the sixth kind is slower; for the points on the surface are larger, or the matter forming the surface is heavier, and, therefore, not so adapted to vibratory motion, as the extremely light points in the particles of the third and fourth kinds. But since the matter on the surface of particles of the sixth kind is not too heavy to prevent its being well adapted for vibration—for there is the same attenuated matter within and the same yielding quality as in the foregoing—therefore it is also adapted for vibration. The only difference apparently is, that the vibration in the particles of the third and fourth kinds is slower. But although it is very rapid in respect to our senses, the surface is of greater extent, consequently, the path traversed by the vibrating point or particle of the fifth kind is greater. In addition to this it is somewhat heavier, consequently, the vibration in the particles of the fourth kind is exceedingly rapid; also the less the particle of the fourth kind the more rapid the vibration. Then follows the particle of the third kind which has a less rapid motion; and last in this class comes the particle of the sixth kind.¹

115. VIBRATION CAN BE IMPARTED TO SEVERAL POINTS IN THE SURFACE AT THE SAME TIME, THESE POINTS EITHER COHERING OR BEING MUTUALLY SEPARATED, AND YET THE VIBRATION SO IMPARTED MAY PROCEED REGULARLY.

The vibration is least if it moves only one particle or one point in the surface; but it rarely happens that a vibration is so small. Several points or several surface particles may

¹ In the margin of the MSS. these words occur: "Note below, that the vibration in these particles takes place differently, that is, by the reciprocal expansion and compression of a particle."

be set in motion at the same time. For example, if in fig. 77, the surface be struck at *A* by another particle, then not only one, but several points are struck and set in motion. Also the greater repercussion and the greater vibration, so that the vibratory motion can affect much of the surface; nevertheless, since all the particles, or all the points in the surface, flow regularly over the surface, it follows, therefore, that also the vibration itself, although consisting of many points, is regularly distributed over the surface, just as if there were only one point. And the vibration runs the more quickly over the whole surface of the particle, in proportion to its tension and the greater central motion with which it is impelled.

Fig. 77.



The same is the case if the circumference is struck not in one place only, but in several; so that if it is struck on all sides by neighbouring particles, then the vibration once regularly started at several points extends throughout the surface and completes its course, just as if it had been touched in one point only.

116. THE ATTENUATED ENCLOSED MATTER REACTS AND, CONSEQUENTLY, THE VIBRATION IS GRADUALLY DIMINISHED.

The greater the motion of the surface, as in the compressed particles of the fourth kind, the greater and more rapid the motion of the attenuated enclosed matter; and, consequently, the greater the reaction; so that the enclosed matter moved by the same gyration as the surface expands the surface, and consequently reacts, and strives to bring about the normal condition of the surface, and to obliterate all the motions that have arisen in it. Hence the attenuated matter reacts more strongly in such cases than in those where the motion is less. This also is the reason why the vibration is gradually diminished; and when it runs over the surface, it gradually vanishes. For the vibratory motion is bound to extend as far as the centre, and from the centre it then goes throughout the entire circumference. This motion rather tends to wipe out the vibratory

than to promote it ; consequently, it has hardly run its course before it has extinguished the motion that has arisen.

117. AN UNDULATION IS A GREATER AMOUNT OF VIBRATION
CONJOINED WITH THE MOTION OF THE CENTRE.

We have treated of vibration, which is nothing else but a kind of action and reaction of the periphery, the motion of the centre being stationary. But when the vibratory motion is so increased that the whole particle with its centre is moved from place to place, that motion is designated undulation.

It is evident from these things, that the terms vibration and undulation are thus applied respectively to the surface and the centre, or to motion in the surface or motion with the centre. For example, if there be any large vortex, as that of the sun, then if there be repercussion in the vortex itself, the sun or the centre remaining quiescent, then there is said to be vibration only in the vortex, although the particles of which the vortex consists have an undulatory motion. So also in the case of a particle which has other particles either in the surface or enclosed in it, if the surface particles undulate or even the enclosed particles do so, the larger particle may be said to vibrate ; for it does not set up motion in its centre. Thus we understand by undulation that motion in a particle is set up at the same time as that in the centre.

118. A CERTAIN UNDULATION IS SET UP IN THE SOLAR VORTEX
AND ALSO IN THE PLANETARY VORTICES BY THE SUN'S
MOTION.

The sun itself, which is the centre of the large vortex, is filled with very attenuated matter, and, since it is closely surrounded with very light matter or particles of the third and fourth kinds, therefore it is not wonderful if it should continue to flow into that centre or solar ocean ; but, since all that ocean round that centre is in motion, and carries all the circumfluent matter with it, which, continually but slightly resists, and continually tends to that centre because of its extreme lightness, therefore

it is not wonderful, that there is definite uninterrupted resistance and repulsion of the circumfluent matter. It also happens that new attenuated matter seems to flow continually through certain poles. For these reasons, therefore, the sun in the centre of the vortex acts like the heart or the lungs in man. So, too, it continually strives to remove from itself the circumfluent matter. Consequently there arises a definite motion in the centre of the vortex which, after the manner of an undulation, is dispersed thence throughout the whole of this vortex. Also a certain undulatory motion arises from the stars, which passes through their vortices and penetrates the vortices of other stars. In the same way fire sets up an undulatory motion in surrounding matter ; for it always strives to enter it, but is unable, consequently a kind of undulation begins and extends throughout the whole volume, which consists of the same particles.

119. PARTICLES OF THE THIRD, FOURTH, AND SIXTH KIND ARE PARTICULARLY SUITED TO TAKE UP UNDULATORY MOTION AND COMMUNICATE IT TO NEIGHBOURING PARTICLES.

There is no body or particle more adapted to take up and communicate undulatory motion than particles of the third, fourth, and sixth kind, to say nothing of those which we have hitherto treated. These particles came into existence and were made for such motion.

1. One rests upon another so that it presses on the surrounding particles by contact. For when the vortex is formed, and the motion tends from the centre to the periphery, or from the periphery to the centre, then one particle presses directly on another, or, from a certain effort and weight received from those above, one rests upon another, so that there is a continuous nexus, or an unbroken connection, which would not be the case unless, by means of motion, the matter constituting the particles was formed into a vortex. So great is the connection that one particle is continually pressed upon by another, and the more remote the motion is from the origin, the more the force of pressure is increased by the altitude.

2. Another reason is, that all particles of the third kind, as also of the fourth and sixth kinds, are perfectly spherical, so that there cannot be a form more spherical ; for within is the attenuated enclosed matter, which plays the part of a vortex, and everywhere sends forth radii, as it were, from the periphery to the centre. In the surrounding vortex also radii are sent out from the surface to its exterior periphery. Consequently, the surface is very gently set in motion between two vortices which exert contrary effort ; for the surface lies, as it were, in their womb and bosom. Hence the form is not only perfectly spherical, but also, because of the exceedingly rapid motion of the surface, the sphericity is subject to extreme tension ; this is still more the case with a particle of the fourth kind. As a result, therefore, of these properties it follows that it is perfectly adapted to receive impact from every direction, and of communicating it with perfect regularity to those in the vicinity. Consequently, there can be nowhere a more perfect figure, for taking up such undulation than that which we find in particles of the third, fourth, and sixth kind.

3. Such particles are also perfectly equal, and of the same size in the same circles of their own vortex. For if there were inequality in the particles, one being greater than another, and thus an element were formed of greater and smaller particles connected irregularly, the undulation must necessarily become irregular. But since all the particles are perfectly equal, therefore they are completely adapted for communicating the undulatory motion which they have received to everyone and with perfect regularity. For although the particles in the vortex are compressed, and the lesser ones find an exit the nearer they are to the centre of the earth, still there is perfect regularity, because diminution takes place according to the distance stated ; and because it is of the same amount in every circle of the vortex, the diminution by compression proceeding with perfect exactness.

4. In addition to this the particles are enclosed by vortices that are in perpetual motion ; and, since the motion in all is

very rapid, and homogeneous, they very greatly assist contiguity ; for directly one strives to enter the vortex of another, an undulation or movement arises on account of the motion of each.

Since, therefore, the said particles of the third and fourth kind, as well as of the sixth kind, are perfectly adapted, and, as it were, born and made for taking up and communicating undulation, therefore also, it is not to be wondered at that nature can so admirably sport with that undulatory motion, and by means of it produce such beautiful and delightful phenomena, of which we must treat when we take up the question of light and heat. And the more so because there can be no body in nature more perfect than these particles, which have a perfect uniformity of motion, figure, mass, weight, and position. Neither can a body or particle of any kind enjoy a more perfect elasticity.

It is known by experiment that spherical elastic bodies impart and take up the force of impact arising from the motion of adjacent bodies. If, for example, a single elastic sphere impinges upon another, both being in motion, each would take the force of impact or motion from the other, and each would impart its own force to the other. If one sphere were in a state of rest, and the other in a state of motion, the quiescent sphere would take up the motion of the other, and the sphere in motion would share the inertia of the other, and contrariwise. Similarly, if ten or a thousand or more such elastic spheres were in contact, one sphere would communicate its motion to the remotest sphere; two spheres would communicate their own motion to the two remotest spheres ; and, consequently, the greater the primary motion, the greater the final motion in elastic bodies.

Since the particles of the third, fourth, and sixth kinds are perfectly regular and elastic, and maintain a perfectly regular situation, so that one undergoes pressure from many others, and with most perfect uniformity, it is bound to happen, that at the first impact, which, we take it, arises in the sun itself, the particles most remote therefrom, an opening having been given, will take on an undulatory movement ; and this undulation will travel not by a definite fixed path to more remote parts, but

will proceed everywhere in all directions, so that it will extend itself as a sphere, and into all the surrounding surfaces, nor will it come to rest unless something retards the course of the undulation, or turn aside its course. It will be neither diminished nor increased, unless it enters into matter that is lighter or heavier, more distended or more compressed. We shall refer to this below.

120. AN ELEMENT WHICH IS SUBJECT TO AN IMPACT, OR CAUSED TO TAKE UP AN UNDULATION, DOES NOT UNDULATE THROUGHOUT THE WHOLE OF ITS PATH, BUT ONLY IN THAT PLACE WHERE IT HAS A DEFINITE OPENING, OR WHERE THERE IS NO OBSTACLE THAT CAN RESIST THE UNDULATORY PRESSURE.

We have stated in the preceding pages that the general undulation in our vortex arises from the sun's motion which strives to bring all the surrounding matter into synchronism with that motion. Still it cannot be said that all that matter which extends from the sun to us is urged into undulation, and that the undulating volume reaches as far as our earth. For if the whole atmosphere, or all the matter contained in the vortices were in a state of undulation, there would be a kind of infinite motion in which mutual disturbance would be set up, and contrary action and infinite collisions would take place there. This undulatory motion begins indeed from the sun or from another source, still it does nothing more than exert pressure upon the surrounding matter, so that it cannot be called undulatory motion, but only undulatory pressure.

But when something opposes the pressure, which gives way before the pressure due to undulation, so that there is no resistance in another direction, then first a kind of undulatory motion is set up, which derives its origin from the said pressure due to undulation. For example: if undulatory pressure meets a very thin membrane, which easily takes up motion, then it undergoes pressure on one part according to the impressed undulation, and thus it takes up a certain amount of

motion of undulation. For the membrane is of such a nature and so thin that the matter is unable to pass through or be turned back by pressure, unless it is moved by the pressure imparted to it. This, however, does not imply that there is a similar undulation and motion in the said element, but merely that the pressure is of a similar nature which is put forth when a corpuscle meets it which does not rest but yields to the pressure. So that if a certain part were void of matter, but everywhere surrounded with matter subject to a pressure that accorded with that undulation, then, at the farthest limits, or where that matter ends and meets with a vacuum, undulation and undulatory motion arises, and nowhere else. Just as is the case with water which undulates on the surface, the undulations being apparent to the eye. But this takes place because the surface of the water is acted upon by the lighter atmosphere, consequently the undulatory motion becomes visible in that place. But if such undulation originated in the depth of the sea it would extend only to a small distance; elsewhere it would receive merely undulatory pressure.

In order to better illustrate this, let there be ten or a thousand elastic spheres arranged in order, and let an elastic sphere impinge upon the first sphere in the series, then the last or tenth or the hundredth in order alone takes up the motion and partakes of the undulation; but not the intermediate ones, which remain perfectly quiescent, one pressing against another.

It follows from these things that an undulation has the same qualities as a bare pressure; but what the nature of that pressure is in elements must be stated elsewhere.

121. AROUND THE ORIGIN OF MOTION THERE IS SOME UNDULATORY MOTION, BUT THEN IT IS MERELY PRESSURE WHICH RUNS OUT AGAIN INTO UNDULATORY MOTION WHERE THE PRESSURE CEASES.

This proposition has been explained for the most part in the preceding paragraph. Now it cannot but happen that around the origin of motion, greater or less motion of undulation will

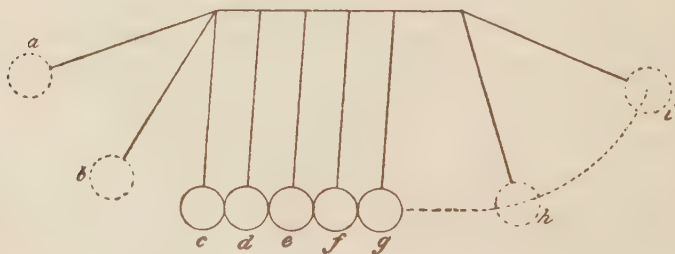
exist, but because of the elasticity of the neighbouring particles, they do not move far from their place, but the particles themselves undulating in their own surfaces, give place and yield; but they impart pressure to the rest, which pressure, like an impressed undulatory motion, is continued for an immense distance. That pressure then causes almost the same undulatory pressure in the place where something meets which gives occasion for the pressure, as we have before stated.

122. THERE ARE GREATER AND SMALLER UNDULATIONS OR DEGREES OF UNDULATION OF VERY DIVERSE KINDS.

Here I do not yet speak of a diverse undulation originating at a distance which is traversed by pressure, nor of the diversity which arises from the varying magnitude of the particles, but of the diverse beginnings of undulations. For it is possible for undulations to be greater or smaller, according to the primary amount of pressure. For if a definite elementary volume is forcibly struck, a pronounced undulatory action will arise.

If an element had undulations imparted to it by that fiery ocean or sun, a somewhat forceful or pronounced undulation would result; and if the undulation were small the source or sun would be small. For the greater the magnitude of the source, the greater the pressure arising, and the greater the

Fig. 78.



undulation, where an undulation is capable of coming into existence.

The case would be like that of a number of elastic spheres (fig. 78), *cdefg*, which represent the structure of an element,

If the sphere h is dropped from the position h , then the last sphere in the series will not take a higher position than b ; but if the same sphere be raised to i , and dropped from that position, then the vibration and impact will be greater; so that the last sphere c will rise to the position a ; hence according as the impact is greater or less, or the place of origin higher a greater or less undulation will arise in the farthest limits, as also a greater or less pressure midway, as in $cdefg$.

Similarly, there will be a greater or less undulation, if it starts from several particles, or from a greater volume of them. If, for example, at h there were two or three elastic spheres, which impinged with a given force on a series of spheres $gfedc$, then on their part the two or three spheres would swing as far as b with the same force, and thus there would be different degrees of undulation according to the greater or less amount of the force of the primary impact.

123. THE DIFFERENCE IN THE UNDULATORY PRESSURE IS PROPORTIONAL TO THE DISTANCES.

Although such pressure or undulatory quality may be propagated to a very great distance, still the pressure is bound to decrease gradually, unless there is a cause at hand which either increases the pressure or renews it. Indeed the particles lie in the whole universe like an unbroken chain, so that there is nothing that is not touched by many of them at the same time; and that contact is exactly alike in all; nevertheless the pressure is greater if there is a greater incumbent volume. Since, therefore, the particles in their own vortices, are connected like a chain, it would not be wonderful if that pressure were extended to a very considerable distance; for the particles are extremely sensible to motion, touch, and pressure, as we have previously stated. Still, since the particles are elastic, the force of pressure must gradually diminish, especially if extended into a very ample space. Hence such pressure also may be diminished, and at length it may vanish, although the condition resulting from the pressure may continue for a very long time.

124. IF THE UNDULATORY PRESSURE IS PROPAGATED ACCORDING TO THE GENERAL PRESSURE OF THE VORTEX, IT WOULD SEEM TO BE AUGMENTED ACCORDING TO THE DIFFERENCES OF THE VOLUMES INTO WHICH IT TENDS.

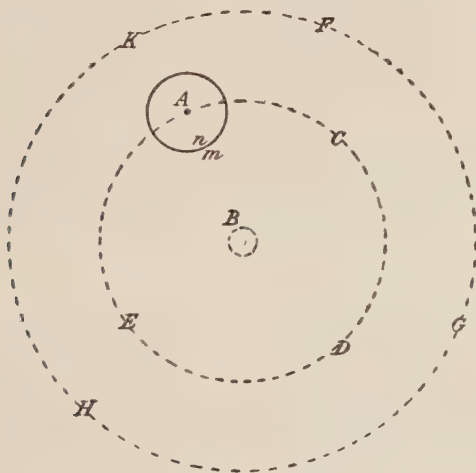
If we turn our thoughts to the consideration of the great solar vortex, and of the earth, we gather from the preceding considerations that particles are forced by the sun to all the peripheries of that vortex, so that there is a pressure directed toward the peripheries; and, consequently, the particles are pressed together. Since, therefore, there is such a pressure, and indeed a centrifugal pressure, it therefore follows that all the particles undergo pressure according to the distance from the centre, and consequently they decrease in magnitude, so that a particle near the sun is greater and more dilated than a particle near its remoter peripheries.

But in the vortex of the earth there is a pressure from the periphery towards the centre, and a kind of centripetal tendency, and, consequently, the particles there are subject to pressure. One particle rests upon another from the peripheries of the vortex to the centre; and therefore the particles nearer the centre are less dilated or more compressed than those which are at a great distance from the centre in that vortex. It is consequently especially evident what are the nature and connection of the particles from the sun to the centre of our vortex.

If, in fig. 79, the source of motion or the sun is in the centre of the great vortex *B*, because in it there is a certain centrifugal tendency, then one particle rests upon another, and is thus forced to the peripheries from *B* to *K*. Let *A* be the centre of the earth's vortex, or *ACDE* the circle which the centre of that vortex will describe. In that vortex of the earth there is a certain centripetal tendency, and, consequently, one particle rests on another from *m* to *n* as far as *A*; and therefore, from the sun *B* to the centre of the earth's vortex *A* there will be a certain pressure which thus extends in a right line from the sun to the centre of the earth. The same pressure will be increased

in the vortex of the earth from *m* to *A*, since the pressure is not only according to the general pressure or that of the great vortex, but also according to the new or second pressure which the motion or pressure of the vortex itself causes. Consequently

Fig. 79.



it may be seen that the pressures extending from the sun to the centre of the earth are in the highest degree harmonious; nor is one contrary to another, but rather the one assists the other in handing on the pressure.

It follows, therefore, as a result of such mutual resting of particles one upon another, that the compression of a particle is greater, and that the particles are less in their order from the sun to the centre, in proportion to the distance through which that pressure or undulatory character directly extends.

Hence we see that the undulating pressure extends from the more dilated to the less dilated or more compressed particles; and, consequently, that undulatory pressure is taken up by the heavier volumes. On account of this quality nothing else can happen but the increase of the undulatory quality from the sun as far as the earth's centre. The particles themselves become less and less in proportion to their distance from the sun, and consequently they have greater velocity, and come more

into contact with those in their own neighbourhood. The elastic force also increases; for the less the particle, the greater its velocity; and, consequently, the greater the elasticity, the more quickly does the surface recover itself on receiving any impression. Also the volume of such particles becomes heavier; for the matter contained in a smaller, is the same as that contained in a larger volume, when the particles have been dilated. For these reasons it follows that the undulatory pressure grows and increases the more it extends from the sun to the centre of the earth.

But if the pressure takes the opposite path, it would seem that it gradually diminishes; nor is it propagated to the same distance with the same force.

125. THE UNDULATORY PRESSURE OF THE ELEMENTS DIFFERS FROM THEIR GENERAL PRESSURE.

There is a general pressure of the elements, because it is exerted toward the centre in the vortex of our earth, and also because that pressure extends spherically, so that there is an equal pressure upwards, downwards and laterally, according to the amount of pressure arising from the altitude. There are also other properties in the general pressure of the vortices which do not agree here with the undulatory pressure. But the undulatory pressure is propagated in a right line, and follows the radii which proceed from the source of motion; nor does it dissipate itself laterally or in another direction; but it takes a straight path from the given source. For there is no reaction; nor is a particle driven laterally or in a backward direction, as in the general pressure; but the action simply proceeds uninterruptedly along the radii or right lines from the source of motion. For if there were any reaction then that pressure would be like the general pressure; but there could not be such reaction unless a definite vortex were formed. From such a source of undulatory motion there could be formed no vortex that would run out into gyres and circles; but pressure without a vortex would be produced; and since the cause is not the

same, the same effect would not follow. Consequently such pressure, without the formation of a new vortex, or without a spiral or surface circulation, would proceed directly from the place of origin along radii running out into the universe. Nor would there be anything that could react or convert the pressure into any kind of reaction or turn it into all the directions that the surrounding particles might take.

126. UNDULATORY PRESSURE IS AT ONCE ARRESTED BY AN OPPOSING OBSTACLE, NOR CAN IT GET BEHIND IT, UNLESS IT CAN PASS DIRECTLY THROUGH ITS PORES. THE UNDULATORY PRESSURE IS REFLECTED AT THE INCIDENT-ANGLE BY ANY OBJECT WHICH IT CANNOT REGULARLY TRAVERSE.

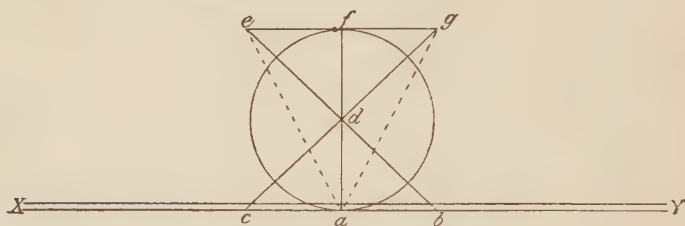
That the undulatory pressure is at once arrested by an opposing obstacle is a consequence of what has been previously stated; for since there is no reaction or return pressure on the part of the particles; or since there is a general similarity of pressure, and since the pressure takes place along right lines and along radii from the source of motion to the peripheries, it also follows as a consequence that it stops there, if there is an opposing body, and that there is no such pressure in the rear of the opposing body. For if there were reaction in the undulatory pressure, or if the undulation formed a kind of vortex, in which there was a centrifugal or centripetal tendency, then there would also exist an undulatory pressure behind the body; but, according to what is stated in the preceding paragraph, such pressure is absent where there is no capability of traversing the body.

But if the opposing body is such that matter can pass through it, and such transmission can take place regularly, then also the said pressure or undulatory influence may extend to the rear of the body.

That undulatory force or pressure can be reflected from an obstacle according to the angle of incidence is quite evident from experiments both in physics and mechanics, such experiments, or laws being capable of geometrical explanation. For example

let (fig. 80) there be a suitable particle of the third, fourth, or sixth kind, this being so small that the lines gc and ga would be practically parallel as seen by us, for the part subtending the angle g would be almost negligible. Let XY be the object on which the particle impinges, that is, let it be carried from g to strike the

Fig. 80.



opposing body at a . When it impinges at a , in consequence of the elasticity of the body, the particle will be reflected by the resilience of the opposing body, therefore it tends to take the perpendicular path a to f , and also the horizontal direction a to c . As a result of being opposed, it takes two directions, one from a to X horizontally, the other from a to f perpendicularly. Since the impact takes place at an angle, therefore the force along the horizontal line aX to the force along the perpendicular af , is as fg to fa , according to the well-known rule in mechanics. Consequently, when the particle endeavours to proceed from a to X under the influence of the force gf , and strives to proceed from a to f under the influence of force fa , it follows that these forces are compounded and that it proceeds in the direction ae ; for $fe = fg$. Therefore the diagonal is ca , whence the angle eaf is equal to the angle gaf ; that is, the angle of reflection is equal to the angle of incidence.

Since, then, the particle is forced from g towards a and remains under pressure, on an opening being given, it immediately exerts pressure upon the volume of particles along the given direction, and is reflected at the same angle at which it impinged.

127. THERE MAY BE MANY THOUSANDS OF SUCH UNDULATORY PRESSURES IN ONE VOLUME, NOR WILL ONE IMPEDE ANOTHER ; BUT EACH PRESSURE WILL COMPLETE ITS OWN UNDULATION WHEN THE OPPORTUNITY IS GIVEN.

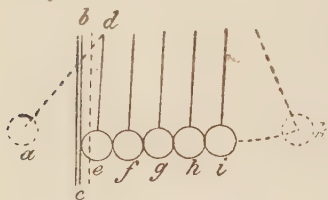
In the preceding pages we spoke of the sun as the sole source from which the undulation proceeds into all the circles and parts of its vortex, and which also sends its undulations into the vortices of its planets or orbs. But here I assume that there are a thousand such sources, or suns, as there are many thousands of stars which are like suns in their vortices ; but they appear to us to be less luminous and smaller by reason of their distances. Besides in our vortex there may also be many sources of motion. As, for example, if there are fires in many places, so there will be reflection from thousands of places. For when an undulation is reflected from objects and at the angle of incidence, then reflection may take place at a thousand places ; and not from a thousand only, but from an infinite number, from which an undulation started by the sun is reflected and modified, and although such undulation proceeds from such infinite sources, still it is able to give rise to regular undulatory pressure in that elementary matter.

It is clear from these things, that elementary particles are not urged into any undulatory motion, but that instead of motion there is undulatory pressure or influence, which passes into undulation if there is nothing to prevent it, or if a body comes into contact with them, which is capable of being impelled to take up such motion. It is clear also that this pressure, arising from so many sources, is distributed without disturbance among the particles, so that if the pressure on a particle is from above or below, at any angle or laterally, that particle takes up such pressure and communicates it to the neighbouring particles in a right line, the radii therefrom extending to all the peripheries. The particle is thus under pressure in every direction, still it will not move unless there be opportunity or an opening.

In order to see this illustrated, consider fig. 81. Let *efghi*

represent a collection of particles, placed here simply in a straight line. If k impinges or oscillates against the series, then all in that series will remain in their normal position except the last, e .

Fig. 81.



If any obstacle is in the way, as bc , so that the globe e cannot depart from its position or oscillate, then it remains where it was. But if the obstacle is removed, then e will fly off to a under the influence of the same undulation as k . If the obstacle is thin,

like a membrane of some kind, then it takes up that pressure, the membrane, however, cannot remain quiescent, but takes up the said undulation. Consequently, the last particle cannot undulate unless it is free so to do; but if nothing prevents, then it immediately acts in agreement with the undulatory motion. It follows, therefore, that only the first and last particles in the series manifest the effect of the undulatory motion, the intermediate ones remaining stationary.

Similarly, if the small spheres do not lie in a right line, but are grouped in a volume of globular form, then, if the undulatory motion affects such volume at one or a thousand points, the particles forming the volume will suffer pressure at a thousand points, and they will be at rest under such pressure; but if an opening occurs at any part, the particle will be affected by that undulation which is strongest, and which proceeds from the opposite direction. The remaining pressures will be exerted, but with a difference.

But in regard to the taking up of the undulations, as to whether this takes place in a very thin membrane, or where an opening occurs, many points worthy of consideration might be brought forward. For instance, one little membrane might be able to take up a thousand undulations; one undulation without any impediment might pursue its path through the undulating part of another membrane, so that one undulating part might be able to pass to the rear of the undulating parts of a thousand

others. For an undulating membrane must be considered just as tense and even tenser than if it were not undulating; indeed it will have greater tension than if unaffected by any undulation. Hence, although the membrane is not flat but curved, still many other parts in the same membrane may be able to propagate waves, just as if the membrane were stretched or flat.

The same is the case with the undulatory pressure of particles of the fourth and sixth kinds. A volume may be variously subject to pressure, and the pressure may then run out into an undulation, when opportunity offers; and, indeed, with variety, because the pressure or undulation of one impedes the pressure or undulation of another. But we must treat separately concerning undulation in membranes and in solid bodies.

128. PARTICLES MAY BE VARIOUSLY REFLECTED FROM SOLID BODIES, IF THEY ARE OF REGULAR FORM.

When some particle under pressure from an undulation falls upon a flat surface it rebounds or is reflected at the angle of incidence. But if, when still under the influence of undulation and after reflection, it falls upon another plane surface, it will again be reflected at the angle of incidence; and the same will be the case on third and fourth reflections.

It consequently happens that this pressure, because of diverse reflections and inflections, turns out to be exceedingly varied, and

Fig. 82.

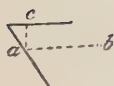


Fig. 83.

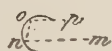
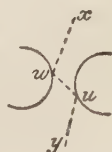


Fig. 84.



Fig. 85.



sometimes it becomes so mixed that hardly any regular reflection is able to exist. For example, consider fig. 82. If the undulation or pressure proceeds from *b* to *a* in a straight line, but is received at an angle at *a*, then it is reflected thence to *c* according to the angle of incidence, and at length goes on its way. If

the undulation, fig. 83, proceeds from *m* to *n*, from thence to *o*, and so to *p*, then it is twice reflected before it proceeds on its path. If, as in fig. 84, the undulatory pressure proceeds from *q* to *r*, thence to *s*, and so to *t*, then it is clearly further reflected, and another modification of the undulation takes place. So also if the undulation proceeds after various reflections have taken place. As, for example, in fig. 85, if it tends from *x* to *w*, then from *w* to *u* and leaves from the other side. So too it may undergo reflection so as to leave in a direction opposite to this. Such variations may be infinite, and the more there are the more will be the varieties of pressures in the volumes, and the varieties of phenomena appealing to our senses, and the more sources and origins of undulations will there be. But more on this subject when we treat of experiments and the mechanical means for experiments.

129. THE REGULARITY OF THE PORES IN OPPOSING BODIES IS THE CAUSE OF THE PASSAGE OF AN UNDULATION ; IRREGULARITY IN THIS RESPECT LEADS TO THE CONFUSION AND DISAPPEARANCE OF UNDULATIONS.

That an undulation can proceed from the sun, and pressure from the sun be maintained through so great a distance as to our earth, arises from the perfectly regular arrangement and connection of the particles. For if the particles were not exactly alike, and their arrangement perfectly regular, neither undulation nor pressure could be transmitted through so vast a space. Therefore, when any object or body offers opposition, in which there are pores having such regular arrangement that the order of the particles cannot be disturbed without the undulatory pressure being propagated in another direction, then such pressure will be transmitted, although suffering diminution on account of the regular bodies which oppose it. But if the pores are irregular, so that the pressure or undulation which is transmitted passes on irregularly, then pressure does not make itself manifest elsewhere but is lost, as it were, although the particles themselves are quite able to transmit it.

130. THIS UNDULATORY PRESSURE IS THE CAUSE OF SIGHT,
LIGHT, AND COLOUR.

This undulatory pressure extends uninterruptedly from the sun to our earth. And because on the earth there are various forms, a variety of greater and smaller bodies, various kinds of salts, earths and metals, and a diversity in the form of their minute parts, therefore undulations are bound to be differently reflected, and, on being so reflected, to strike against the membranes of the eye. As, therefore, there is in light nothing which cannot be explained by the rules and mechanism of undulatory pressure, and nothing in undulatory pressure which cannot be observed in light, and nothing in light and undulatory pressure which is not received in the eye or organ of sight, therefore all these things are shown to be true when they are compared experimentally with the principles themselves and with our theory. Here we can deal with these in a general manner only, a more particular knowledge depends on experiments and the comparison of these with our theses.

Moreover, if you examine, and explore the bodily sensations you will see a kind of mechanism extending throughout the whole body, and particularly in the case of the eye, which co-operates to take up undulation by means of the senses. How great is the number of nerves in the body, and how numerous their interlacings and connections, one supporting and helping another! How manifold are the membranes everywhere connected with the nerves themselves and the bones also! What attenuation and continuity, what intercommunication among the membraneous coverings of the brain! What expansion of these by means of the blood-fluids and nerves, and what colour do those fluids possess! As to the eye itself, its structures lie outside the skull and are made evident by radiating fibres, as it were, and protected also by various coverings.

Since, then, the extremely attenuated coverings of the brain, the pia mater and the dura mater, extend to the radiating fibres in the eye, the most minute undulations must be taken up by the

membranes and retina of the eye, just as undulations of greater amplitude are taken up by the drum of the ear. If then you could see the structure of the membranes of the eye, and those concerned with more subtle organs, you would be amazed to perceive that the whole arrangement is nothing but a mechanism for the taking up and distributing the waves that impinge on the membranes. Here you would find a field in which you could examine the mechanism of more subtle undulations, and investigate the paths and courses of the more subtle sensations in the human body, and discover how that mechanism extends beyond the limits hitherto assigned to it.

Nevertheless, it can be said that in the senses there is nothing but a kind of mechanism which is adapted to receive undulations, with this difference that one organ is able to take up the undulations of a more subtle element with its particular variety, while another can take up undulations of greater amplitude. Consequently in the corporeal system we find not one but many membranes. The bones are invested with their own membranes. In the ear there are the stirrup, the hammer, and the anvil for communication with the drum, the cochlea for dilatation, and the nerves for conveying the undulations of the air to the coverings of the brain, and then from these to the entire nervous system.

131. UNDULATORY PRESSURE AFFECTS THE SMALLER PARTICLES WHICH FLOW BETWEEN THE LARGER ELEMENTARY PARTICLES ; AND IT IS NONE THE LESS EXERTED ALTHOUGH THE LARGER ELEMENTARY PARTICLES FLOW BETWEEN.

As to the undulation, or this undulatory pressure, it is not in the air-particles, for the undulation acting in these is grosser, and pertains only to the organs of hearing, where it is taken up by grosser membranes. The undulation, or the undulatory pressure which is the cause of light or the sensation of sight, belongs, however, to particles of the sixth kind, which have been very greatly diminished and compressed in the neighbourhood of the earth. In fact this kind of undulation arises in the sun, and extends thence to our vortex by means of particles of the

third and fourth kinds. But if it be considered that this undulation, or this undulatory pressure, increases very greatly while it is passing from the sun to our vortex—for it proceeds from expanded and lighter particles to compressed and heavier particles—then it follows that this pressure has undergone such great increase that the particles of the third kind, which are in the vortex of our earth, press forcibly upon the particles of the sixth kind, which are true particles of our vortex, and are designated under the common name of particles of the ether. And when the pressure becomes so great, the undulatory pressure is bound to be transferred to and be communicated, as it were, to particles of the sixth kind. Let us, therefore, regard them as being subject to undulatory pressure.

132. IF AN UNDULATION IS DEFLECTED BY SOME OBJECT, AND, EVEN IF IT TENDS IN ANOTHER DIRECTION, STILL THE EYE CAN ONLY CONCEIVE IT AS PROCEEDING TOWARD ITSELF IN A STRAIGHT LINE ; BY SUCH PRESSURE VISION IS VERY LARGELY, BUT NATURALLY, SUBJECT TO DECEPTION.

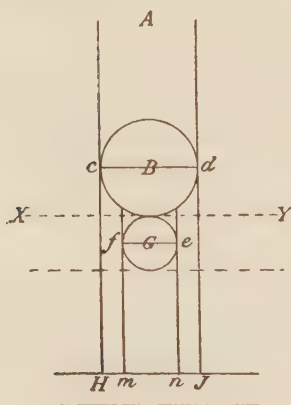
Undulatory pressure tends to proceed along a straight line from the source of the undulations, hence undulatory motion is in the source itself only. As, for example, in the eye undulatory motion takes place in those two extremities only, the optic nerve or the extremely subtle membranes of the eye, and nowhere else ; intermediately there is nothing but undulatory pressure which proceeds by a direct path to the eye from the source of motion. When, therefore, this undulatory pressure is refracted in the manner previously stated, so that the angle of incidence is the same as the angle of reflection, then the pressure at the point of incidence is the same as in the path of incidence, and in the path of reflection proceeding from this point. Since, therefore, an undulation is perceived only along a right line, then that source of motion is bound to be seen along the right line, as is evident in the case of mirrors. For the vision cannot be deflected along a curve or angle ; and the pressure is the same at the point of incidence as at the point

of reflection, and further the particle or the volume of particles subject to pressure which represents the line of reflection is the same as those which represent the line of incidence. Consequently the eye supposes everything it sees to lie in the same line. And so our vision is subject to illusion, and the eye sees shade as light, and takes what is fictitious for what is genuine.

133. A BODY EXISTING IN AN ELEMENT WITH SMALLER PARTICLES IS AMPLIFIED, IF SEEN BY THE EYE WHICH EXISTS IN AN ELEMENT CONSISTING OF LARGER PARTICLES ; AND THE AMPLIFICATION TAKES PLACE ACCORDING TO THE DIFFERENCE BETWEEN THE PARTICLES IN THE MEDIA, AND CONTRARIWISE.

Suppose a body or object placed in a medium or element which consists of smaller particles, and suppose the eye placed in the same element, then there can be no amplification. Nowhere can the undulatory pressure be interrupted or turned from its path, consequently the character of the undulation in the organ, or in the nerve of the eye is according to its nature in the source or origin ; as for example if an object and the eye be

Fig. 86.



conceived as placed in the air, or in the ether, or in water, etc. But if the eye were placed in one element, such as the air, and the object in another, such as water, then the undulatory pressure would undergo refraction where the elements met, or where the light passes from one element into another. Of reflection we must treat in the following paragraph, here we can deal only with amplification.

It is well known that any object placed in water appears to be larger when viewed by the eye situated in the air. This arises from the diverse magnitude of the particles. For example, in

fig. 86, let the magnitude of the water particle be represented by G , and let its diameter be fe ; let the air particle be represented by B , and its diameter by cd ; and the surface separating the water and the air by XY , the upper portion being air, the lower portion water. Let the object placed in the water be HJ , and let the eye in the air be at A . When a ray passes from the object to the surface in G , or to the particle of water lying in the surface, then part mn of the object ought to be seen at f and e . But since the larger particle B occupies the higher position, whose diameter is cd , therefore the radius or undulatory pressure cannot proceed directly upwards on account of the upper particle, nor can it pass through the particle; but the matter in which the undulatory pressure is propagated flows around the air particle, consequently it ought to appear at c and d , so that the pressure which was at f and e is now represented at c and d , whence part of that object is enlarged; and this varies according to the differences between the particles; that is, as fe and cd or as the diameters, or the areas of the particles. Hence the amplification varies with the medium, for example, oil or spirit, etc., instead of water; and when mn equals HJ . The contrary would be the case if the object were in the air and the eye in water; or if the object were viewed by means of a mirror placed in water, the eye being in the air; for then the object would appear to be smaller, and in fact there would be a variation according to the differences between the particles, as previously stated.

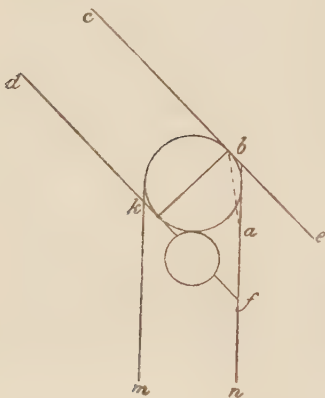
As, therefore, the optic nerve cannot take up the pressure of one particle of ether¹ or one undulatory pressure, but a definite volume consisting of many particles, and an infinite number of particles of the sixth kind, therefore the amplification must be considered as an aggregate of such particles, whose volume is extremely minute so as to be able to affect the optic nerve.

¹ The original is *æris*, but it should evidently be *etheris*. See no. 131.

134. A BODY IN WATER OR ANY OTHER LIQUID HAS LESS APPARENT ELEVATION WHEN THE EYE AND THE OBJECT LIE IN THE SAME PERPENDICULAR; BUT MORE WHEN THE EYE AND THE OBJECT ARE SITUATED IN A LINE THAT FORMS AN ANGLE WITH THE SURFACE.

In the previous paragraph we discussed the amplification of a body placed in various media, from these also as a consequence its apparent elevation can be deduced; see the figure in the preceding paragraph. For when the undulatory pressure

Fig. 87.



appears at d and c , which otherwise ought to appear at f and e , then there is amplification. When also in the same way the altitude of the particle increases, and the diameter of the particle of air is greater than the diameter of the particle of water, then when it appears at d the radius has a greater apparent elevation than if the particle G were in the place of the particle B ; whence the amount of the apparent elevation of the body in water is proportioned to its

amplification; for the cause is the same. It is supposed, however, that the eye and the object are in the same perpendicular line.

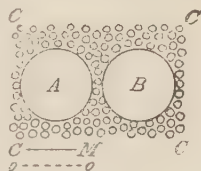
But if in fig. 87 the eye were at dc and the object at mn , then the undulatory pressure would appear at k and b , and ba would be still higher; for the pressure proceeds along the right line from a to b , so that the apparent elevation is greater than a semidiameter, and still greater if the angle is greater. There is also another reason, of which we shall speak in the following pages.

135. GREAT PRESSURE OR UNDULATION IN PARTICLES OF THE FOURTH KIND GIVES RISE TO A SMALL PRESSURE OR UNDULATION IN PARTICLES OF THE SIXTH KIND. ON THE CONTRARY, A SMALL PRESSURE OR UNDULATION IN PARTICLES OF THE SIXTH KIND GIVES RISE TO A GREAT PRESSURE OR UNDULATION IN PARTICLES OF THE FOURTH KIND.

We have stated before that the matter in the tellurian vortex consists of particles of the fourth and sixth kinds, consequently diverse phenomena arise if particles of the fourth kind or of the sixth kind are put in motion. When, therefore, particles of the fourth kind are fluent among particles of the sixth kind, then, on account of the great difference

Fig. 88.

existing between particles of the fourth and sixth kinds, there is also difference between the motions or pressures. In fig. 88 let A and B , be particles of the sixth kind, $CCCC$ those of the fourth kind, then I say that, if the particles $CCCC$ of the fourth kind undulate, in such a way that the undulation is of considerable amplitude, then also the particles of the sixth kind will be able to undulate, but such undulation will be of small amplitude.



For example, let the undulation be of such amplitude as to extend from C to M , then the particle or the volume of such particles of the fourth kind will appear to undergo considerable movement, and that, indeed, through a space which equals twenty, a hundred, or a thousand times the diameters of a particle. By such an undulation also an undulation may be set up in A ; but the undulation thence arising will be small, being equal only to one diameter or half a diameter; for the undulation of particles must be reckoned according to the diameters.

On the contrary if a particle of the sixth kind has a small undulation, as for example if A or B undulates to the extent

of half a diameter, that undulation is only small in reference to that particle ; but by means of such undulation the particles of the fourth kind can be excited to motion, and, indeed, into waves of the same amplitude ; but since this space is equal to a hundred or a thousand diameters of such a particle, that undulation may be regarded as of considerable amplitude, that is, in respect to that particle.

Therefore it follows, that one or more particles of the sixth kind can be moved by a volume of particles of the fourth kind, and, on the other hand, by the motion of one or two particles of the sixth kind, some hundred particles or a volume of particles of the fourth kind can be moved.

When we speak here of undulation, it must be understood that we mean also undulatory pressure, for if it is effective and strong—which can become an undulation when the opportunity is given—then a considerable pressure may communicate a slight pressure to particles of the sixth kind ; and, on the contrary, a slight pressure in particles of the sixth kind produces a considerable pressure in particles of the fourth kind ; for that pressure is undulatory in character, so that it takes the form of waves immediately the opportunity is given. We see from these things how undulation or pressure in one element is able to be communicated to another element, and in proportion to the diameters of the particles.

136. A SLIGHT PRESSURE OR UNDULATION IN PARTICLES OF THE FOURTH KIND CAUSES MERELY A VIBRATION IN PARTICLES OF THE SIXTH KIND ; OR A VIBRATION ARISING IN PARTICLES OF THE SIXTH KIND SETS UP AN UNDULATION IN PARTICLES OF THE FOURTH KIND.

This is a consequence of what has been previously stated. For an undulation is the reciprocal motion of a particle, the particle itself being moved together with its centre ; but a vibration is motion in the surface of a particle, which takes place without affecting the centre. If, therefore, an undulation in particles of the fourth kind be so slight, that it undulates only to the

extent of one of its diameters, then in particles of the sixth kind no undulation can be set up, and consequently the whole particle cannot undergo a change of place ; but every part of the surface can be moved, so that merely a vibration is the result.

On the other hand, when a particle of the sixth kind begins to vibrate, then even a very slight undulation can be set up in particles of the fourth kind. It is the same with pressure or undulatory and vibratory quality ; for when opportunity of passing into an undulation is given it does so, the said pressure or quality meantime setting up undulatory motion remains.

137. VIBRATION IN PARTICLES OF THE FOURTH KIND CANNOT IMPART ANY VIBRATION TO A PARTICLE OF THE SIXTH KIND.

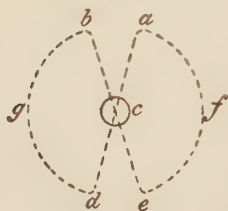
A vibration in a particle of the fourth kind, which is confined merely to the surface, can have no communication with a particle of the sixth kind, so as to be able to set up a vibration in it. For there is such a difference between the surface particles of the fourth and sixth kinds, that one cannot be moved by another. But it must be confessed, that if a considerable vibration occurs in a particle of the fourth kind, a very slight vibration indeed may be imparted to a particle of the sixth kind and the reverse ; but then the amount of vibration in a particle of the fourth kind must be very great for a very slight vibration to arise in a particle of the sixth kind.

138. THE SURFACE OF A PARTICLE OF THE SIXTH KIND, BY REASON OF COMPRESSION, MAY BETAKE ITSELF TO THE CENTRE, AND THERE FORM A SPHERE, AND BECOME LESS AND LESS, WHENCE THERE ARISES A PARTICLE OF THE SEVENTH KIND.

We have said that a particle of the sixth kind has a surface of the same kind as a particle of the third kind, with a difference only in the size of the surface particles. For the surface particles in a particle of the sixth kind are particles of the fifth kind ; and the particles in a surface of the third kind are points of the

first kind, but in regard to the surface itself, and the movement of particles on the surface, it is the same in each case. So that a surface particle of the sixth kind flows spirally and forms polar cones just as a particle of the third kind does ; hence also it possesses the same characteristics, that is, it can be compressed to smaller dimensions, and the surface matter may pass through the polar cones to the centre and by degrees form a kind of globe, which gradually increases in size from the increase of surface matter, turning out at length to be like a particle of the fourth kind, with the difference only that it is larger, and surpasses the former sufficiently in magnitude. There is no need here to say how the diminution arises, if compression operates ;

Fig. 89.



for we have previously stated this in connection with the description of the particle of the fourth kind.

In fig. 89 let *abgdef* be a particle of the sixth kind. If it suffers compression, the surface or part of the surface immediately passes through the cones to the centre, the central sphere *c* being increased, and the size of the particle diminished. From this it is quite clear that a particle of the sixth kind can be very greatly diminished, and indeed from a diameter of a thousand units to a diameter of one unit, so that if the diameter of the larger is a thousand units, the diameter of the smaller may be one unit, or less. For the particles in the surface are very small, as we have previously stated in the case of the particle of the fifth kind. Hence, when the whole surface passes into a single small globe, it may become quite small, so that such a particle may be more and more diminished, even to more than the thousandth part of the surface ; and, consequently, in the duplicate ratio to the body itself of the particle, or to the volume of the particles.

Since, therefore, a particle may be so compressed, it would not be remarkable if the difference in their magnitude differed to such a degree that the diameter of this particle with such an

origin measured 900, 800, 700, 100, or 50 units; and that the particles should be so dissimilar as to be incapable of comparison as to magnitude.

In regard to compression, we must consider that the particles in the earth's vortex exercise mutual pressure along the perpendicular, and that that compression is everywhere the same. Since then, there is a centripetal tendency in the vortex and the particles rest one upon another, so that one particle exercises weight-pressure upon another, attended, nevertheless, with a circular and spiral motion, it would not be wonderful if the surface matter fell toward the centre, and thus became a particle of less size, yet kept up its own motion among the remaining particles, and preserved its own spherical form. Hence, since it is the nature of a vortex that causes compression, and compression begins in the surface, and continues toward the centre, therefore this particle becomes less and less, until at length, near the centre, it becomes the smallest possible. There are, then, very great diversities of magnitude in this particle.

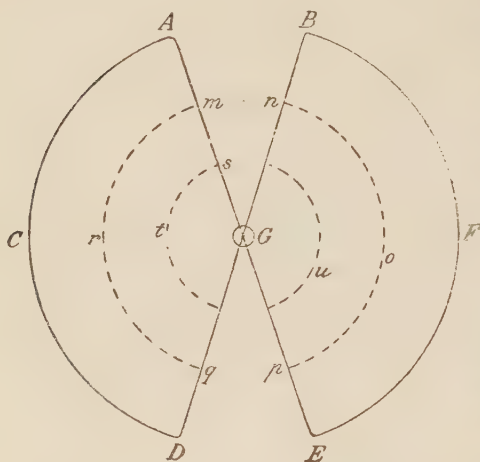
Since, then, the particle of the sixth kind is compressed, and forms a kind of little globe at the centre, either less or greater, merely a kind of globe is formed at the centre, and takes up its position there; therefore, we designate such a particle a particle of the seventh kind. For it differs from a particle of the sixth kind in both magnitude and other characteristics. Here, then, we have the origin and form of a particle of the seventh kind, and also its magnitude, which is very diverse from the rest.

139. A COMPRESSED PARTICLE CAN UNDERGO EXPANSION,
AND THE SMALL GLOBE AT THE CENTRE, AS TO EITHER THE
WHOLE OR PART OF IT, MAY PASS TO THE PERIPHERY.

The particle of the fourth kind may be contracted and its surface diverted to the centre, and, in fact, it may flow through the polar cones to the said centre, and also leave this for the surface; consequently a particle of the fourth kind, having been once contracted or lessened in size may undergo amplification, or return into its original form. The reason for this can

be seen from the centre of this particle, and from the form of the particles contained in the central small globe.

Fig. 90.



From our theory in regard to what we have stated before, it follows that the attenuated matter or that of the second kind is in the cavity of the particle of the sixth kind, so that a circular or spiral motion arises from and is perpetuated by this matter. But the surface of this sixth kind of particle con-

sists of particles of the fifth kind, which are like those represented by fig. 92. From these particles, which constitute the surface, the central small globe found in the particle of the seventh kind is formed, and constitutes there a central small globe, as in fig 92; so that it consists of almost an infinite number of such particles. These particles (fig. 92), or the surface particles of the sixth kind, are of almost the same magnitude as the exceedingly mobile particle of the second kind, or of the surface that constitutes the particle referred to. It follows from this, that the attenuated matter which is in the

Fig. 91.

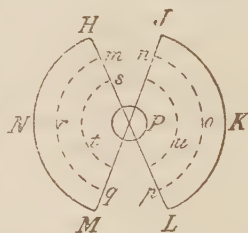


Fig. 92. cavity of the particle of the sixth or seventh kind may also exist between the particles of this small globe (fig. 92), or between particles of the fifth kind. For since they are of the same magnitude, they can be together with, and in the same small globe. These things being granted, let (fig. 91) be a particle of the seventh kind much compressed;



therefore, it also has a larger enclosed globe, and, consequently, the surface of a particle of the seventh kind, as in fig 91, describes more revolutions in the same time than a particle of the same kind (fig 90), although there is the same velocity in the surface. But because the surface is less and the velocity is the same, therefore, more revolutions are completed in the same time. We have previously treated on this point. Consequently, when the pressure is diminished, that is, when a particle of the seventh kind, is not under great pressure from other incumbent or neighbouring particles, then the attenuated enclosed matter and the very rapid motion of the surface causes it to be so enlarged that one particle is nevertheless in contact with a neighbouring one, but when the particle is amplified, the rarified matter in the surface remains, nor does it cohere so well, as to prevent it from being dissipated by the attenuated matter of the second kind. Hence, on account of the amplification, the enclosed matter of the second kind becomes rarified, and, consequently, it cannot act as before upon the central small globe, and, as it were, compress and hold it together. Hence it follows that the same attenuated matter as that which exists between the particles of the fifth kind or between the particles of the central enclosed small globe (fig. 92) is able to act upon the very particles of the small globe, and that it can drive these from the small globe, and very forcibly urge them into motion by a second similar point, and, therefore, through such motion in the cavity of the particle, cast them out to the surface again. So that it may be still better understood how matter of the fifth kind, which is in the sphere of the seventh kind of particle, can return. For as soon as the surface is increased, the pressure of the neighbouring particles being removed, the motion of the enclosed matter is diminished, for this enclosed matter becomes less, and the greater part of it keeps itself in the neighbourhood of the surface, or becomes rarified throughout the whole surface. It hence follows that there is less centripetal tendency in that particle, and that the central small globe suffers less repression. In this condition the enclosed attenuated

matter is able to exercise its force upon the particles of the small globe, and to scatter them one after another, and urge them into a very rapid motion, and so drive them to the surface; and when they come to the surface they repair and restore it where it is wanting. Then new surface matter accrues from the central small globe, which under pressure again returns to the centre through the polar cones. Consequently, compression or constriction of the particle as well as amplification are possible.

For example, in the particle of the seventh kind (fig. 91) let the attenuated matter referred to be represented by *mnopqr* and *sut*, when the surface is increased under diminished pressure (for the surface is increased immediately as the pressure is diminished, since the motion of the particles is in the surface between two vortices, one within, which tends to the centre, and the other without, which tends from the centre to the periphery, hence the surface lies as it were in equilibrium; and the compression being less, and there being a continuous motion of the surface, that surface will be ejected from the centre to the larger periphery, and thus amplify the body or itself), then the same attenuated matter remains, but is more rarified as *mnopqr* and *sut* in fig. 90; and I maintain that new attenuated matter still enters through the poles. The distance, however, from the surface to the centre is greater, and consequently the effect of the vortex or centripetal tendency round the centre is less; for it flows throughout a greater space; hence the matter enclosed in the particles of the central small globes gives rise to a certain force, so that it is able to separate these, dissipate them throughout the cavity of the particle and drive them toward the surface.

140. A VOLUME CONSISTING OF PARTICLES OF THE SEVENTH KIND BECOMES HEAVIER THE MORE THE PARTICLES ARE COMPRESSED ; AND IN CONSEQUENCE OF THE DIFFERENCE IN WEIGHT AND MAGNITUDE, IT GIVES RISE TO DIFFERENT CHARACTERISTICS.

Consider figs. 90 and 91 of the preceding paragraph. If the volume consisted of particles similar in magnitude to those represented in fig. 90, it follows therefrom that a volume of such particles would be very light ; for they would be large and expanded. Hence also a volume consisting of such large and expanded particles must necessarily be extremely light. But if the volume consisted of particles such as those represented in fig. 91, it follows that they must be heavier and more ponderous. And the matter in the particle of fig. 90 is the same as that in the particle (fig. 91). For the surface matter has gone to the centre and remains there ; whence if two volumes were of the same magnitude, but consisted of particles of a different kind, that is, dilated and compressed, one would be light, and another heavy, and they would differ in these respects according to the compression of the particles. Hence one may conclude that a volume of particles in the extreme or highest part of a vortex is exceedingly light, since the particles there are very greatly dilated ; but in the lowest part of a vortex or near the centre, the volume is very heavy, because there the particles are much compressed.

Since the volumes, although the particles are of the same kind, that is of the seventh kind, differ in lightness and heaviness, as the particles themselves differ in magnitude, therefore they take on diverse characters ; the undulatory pressure in the compressed or heavier particles may be stronger and more active, the communication of their motion more rapid and lively. There are many other considerations of which we must treat elsewhere.

141. A PARTICLE OF THE SEVENTH KIND CAN BE COMPRESSED TO SUCH A DEGREE AS TO BECOME NOTHING BUT A KIND OF SMALL GLOBE, THAT IS, IT CAN BE COMPRESSED INTO A QUITE SMALL GLOBE, WHICH WILL BE SMALL IN COMPARISON WITH PARTICLES OF THE SIXTH AND SEVENTH KINDS, WHENCE THERE ARISES A PARTICLE OF THE EIGHTH KIND.

We have treated of this small globe enclosed in a particle of the seventh kind in the previous pages, and also of the matter of which it consists; there is no need, therefore, to deal with it any further; for it consists of particles of the fifth kind. But because the particle of the sixth and seventh kinds can undergo very great pressure, therefore, when there is great pressure, such as exists in the centre of the vortex, then it can undergo pressure until the whole surface vanishes, and with the surface, which was in continual motion, the enclosed vortex. Then at length a small globe arises which wholly puts off a vortical character, and remains a definite hard particle, having no such quality as we have been considering in previous particles, except in those of the fifth kind.

As to the size of this small globe, it is small in comparison with the particle from which it has arisen. For a particle of the fifth kind, which forms the surface of the sixth and seventh particles, is so small that it only equals a particle of the second kind. Consequently, since the surface consists of particles so attenuated, the small globe so formed is bound to be small; for the more rarified the surface so much smaller will the small globe turn out to be, so that the diameter will be scarcely a thousandth part of the dilated particle.

This particle so originating, and, indeed, at the centre of our vortex, is designated a particle of the eighth kind.

142. WHEN A PARTICLE OF THE SEVENTH KIND BECOMES COMPRESSED INTO A SMALL GLOBE OR INTO A PARTICLE OF THE EIGHTH KIND, WHICH TAKES PLACE AT THE CENTRE OF THE EARTH, PARTICLES OF THE FOURTH KIND REMAIN ENCLOSED AMONG SUCH SMALL GLOBES.

We have before said that this compression of particles of the seventh kind so as to become particles of the eighth kind happens in a place where the force of compression is very great ; for it results from two causes. The first is the pressure of the incumbent particles of the sixth and seventh kinds ; consequently, also, on account of the height of the column, the volume of such particles in the lowest part, or near the centre, undergoes pressure, just as is the case with the air, which exerts pressure according to its own weight ; that is, one particle rests upon another, and thus weighs upon another. The second reason is that surrounding particles of the fourth kind also exert pressure, and do so according to their altitude, that is, according to their distance from the sun. Hence when particles of the seventh kind are under pressure, so that a small globe is produced, it follows that the said particles of the fourth kind cannot escape ; and they therefore remain and maintain their position among the particles or globules of the eighth kind, so that they mingle with particles of the fourth kind, which also do not differ much in magnitude from them.

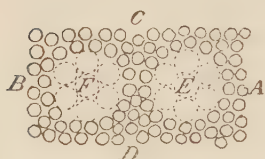
143. FROM THE MOTION OF THE PARTICLES OF THE FOURTH KIND AMONG THE PARTICLES OF THE EIGHTH KIND THERE ARISES A SPHERICAL BODY (BULLA) WHICH CONSTITUTES A NEW PARTICLE ; THIS WE DESIGNATE A PARTICLE OF THE NINTH KIND ; IT IS THE SAME AS THE AIR PARTICLE.

It has been shown that particles of the eighth kind, or the small spheres referred to, could not exist, unless there were particles of the fourth kind between them, the latter having a vortex formed of attenuated matter within and also without :

consequently, they cannot exist without motion. But because the attenuated matter always acts upon the surface of particles of the fourth kind, therefore they can never be at rest, but must be in a continual state of motion. Therefore, although they lie enclosed between particles of the eighth kind or between those small globes, they are, nevertheless, capable of being moved. Therefore these small globes cannot but be urged into definite motion as a result of the motion of the particles of the fourth kind.

For example, in fig. 93, let $ABCD$ be the small globes referred to, or the particles of the eighth kind, E and F particles of the fourth kind enclosed within them.

Fig. 93.



These, because they cannot be without motion, although lying enclosed within, always act upon the volume of the small globes, and at length impel them into the same motion as themselves;

and so from that continual motion they form a surface and the spherical body in which lie enclosed particles of the fourth kind which impart motion to the surface, this surface now consisting of such small globes or particles as are designated those of the eighth kind. Hence we have a new particle, which we may call a particle of the ninth kind; and this particle is identical with the air particle. Thus, then, we have arrived at our elementary matter.

Since then, such a particle has arisen not far from the centre, and since it is heavier and larger than those of which we have already treated, therefore it forms the surface of the earth. It is greater because the surface particles here are greater, and the enclosed matter is a particle of the fourth kind; and this much surpasses in magnitude the particle or the attenuated matter of the second kind. If, then, such a particle could come into equilibrium with the particles of the seventh kind, it must certainly be larger, so that a certain volume of particles of the fourth kind might be enclosed. We shall deal further with this subject below.

144. AIR, OR THE PARTICLE OF THE NINTH KIND, IS SUBJECT TO EXTERIOR PRESSURE BY THREE FORCES, THAT IS, BY PARTICLES OF THE FOURTH, SEVENTH AND NINTH KINDS. BUT INTERIORLY IT IS UNDER PRESSURE OF PARTICLES OF THE FOURTH KIND, WHICH ARE MORE COMPRESSED THAN PARTICLES OF THE FOURTH KIND WHICH EXERT PRESSURE FROM WITHOUT.

Here we must state how the air particle, or that of the ninth kind, is kept together. This results from the pressure of the matter within and the pressure of the matter without. For unless it were under pressure in both directions it could not subsist. But if there are two pressures, it follows that the surface of such a particle can be maintained and the particle itself remain intact; just as vapour whose surface consists of water. But because this is under the pressure of a kind of fluid matter within, and exteriorly is subject to the pressure of the air, therefore, the surface maintains itself and the vapour continues intact. It is the same with the aërial spherical body, which has air within and without.

This air particle is subject to pressure from without, not merely from particles of the fourth kind which flow around on every side. This pressure is sufficiently great, because particles of the fourth kind constitute the matter which is everywhere present extending from the sun throughout all the solar vortices to the limit of the great vortex. Consequently, the first external pressure arises from matter of the fourth kind. The second pressure is due to particles of the seventh kind; for these particles constitute the true matter of the tellurian vortex. Therefore, since this matter begins at the extreme part of the vortex and continues toward the centre, where it is reduced by pressure to small globes, of which the surface of the air consists, therefore, there is a second pressure upon the external surface of the air particle, that pressure increasing from the surface of the vortex as far as the centre of the earth; consequently a pressure sufficiently great, arising from this matter,

exists. The third pressure arises from particles of the ninth kind, or from the homogeneous air particles themselves. For every element possesses weight in itself, and the weight increases in the direction of the earth according to the altitude. So, too, air possesses weight, for one particle rests upon another; and since they all tend towards the centre of the earth, therefore the higher presses upon the lower, or a higher volume upon a lower volume. This is evident also in the case of air. Hence air is subject to its own pressure; and from the air the greatest pressure exists, particles of the ninth kind being heavy enough to produce this. Consequently it is plain that air in elevated places possesses great rarity and undergoes expansion—which is evident from countless experiments—but in lower places it is subject to pressure and undergoes contraction.

But as the air in its interior cavity is subject to pressure from particles of the fourth kind, so that they form a kind of counter weight, it would not be remarkable if they underwent still greater pressure than those of the fourth kind that are on the outside. For enclosed particles of the fourth kind exert the pressure toward the interior surface, just as the particles of the fourth, seventh and ninth kinds simultaneously do upon the exterior surface, the pressure of the former being equal to the pressures exerted by the three latter particles. But in the surface of the atmosphere, where the third pressure does not exist, the interior parts experience less pressure than in the lower part of the atmosphere.

Also it follows that the enclosed particles of the fourth kind have less size because they are more compressed than the particles of the fourth kind which are outside, because they are less compressed. We may see also from these things how the particles of our atmosphere are held together in such a way that they cannot be rent asunder. For each element exercises its pressure equally in all directions. So, too, enclosed matter of the fourth kind exerts a pressure equally distributed on the concave surface of the air, while particles of the fourth and seventh kinds, flowing exteriorly, exert a

pressure equally distributed in every direction on the convex surface of the air.

145. ALTHOUGH AN AIR PARTICLE UNDERGOES COMPRESSION, AND BY COMPRESSION BECOMES LESS AND LESS, STILL IT RETAINS ITS SPHERICAL FORM, AND PRESERVES ITS OWN MOTION AMONG THE EQUALLY COMPRESSED PARTICLES.

Here again another kind of particle is capable of being formed. For there is an air particle which is not compressed by its own air particles, and another which is compressed. But as the designation air is sufficiently well known, therefore we may call them air particles, whether expanded or compressed.

One can hardly wonder that, although such being the form of the air particle, it yet retains a spherical form ; and even when several air particles surround it, that the sphericity of the particle persists. But in order to explain this, and that it may be thoroughly understood, we must observe in the first place, that the external pressure is exerted by means of particles of the fourth and seventh kinds, and that the internal pressure is also exerted by means of particles of the fourth kind, so that there is both an interior and exterior pressure. And although the particles are externally subject to pressure, still there is an equilibrium between the internal and external pressure. Consequently, the sphericity remains whatever may be the pressure. Just as when little bladders of air are formed whether at a great depth in water, or near the surface, they nevertheless preserve their spherical form. So in the case of this particle, it is subject to pressure both internally and externally, and there is an equilibrium in the pressure.

It might be supposed that a kind of inequality will arise in the particles of air when they are subject to much pressure from neighbouring particles, so that there are unequal depressions in the convexity, either because the spherical form becomes octangular, or is subject to pressure by many other particles ; but this happens when such pressure is exercised by neighbouring particles, which possess weight, in such a way that the particle

subject to pressure is passive, as it were, and can merely offer resistance to the given pressure. But here it is different; for one particle undergoes pressure from another and then refers both to the particle causing the pressure and the particle subjected to it; all the neighbouring particles are therefore subject to the same pressure. Therefore, as the pressure is gradually increased in the whole volume of the atmosphere, this whole volume is subject to pressure, and not each particle selectively. Each particle does indeed undergo pressure, but from the neighbouring particles which are subject to the same pressure. Hence I do not see how one particle can be forced by another into any other than the spherical form. For it happens that the exterior particles are of diverse kinds—the ninth, the seventh and the fourth, and granted such pressure, then there is equilibrium between the exterior and interior particles. Also the interior particles are so small that they can exert pressure on each point of the surface, exterior particles of the same kind reacting.

Since, therefore, by whatever exterior pressure the interior particles of the fourth kind are compressed or diminished, they always retain their sphericity; and, consequently, since the interior particles of the fourth kind always retain their compressed state, which equilibrates with the multiplex external pressure; and since they remain unimpaired in form, it follows, therefore, that there is an equal pressure in all directions within and without; and then the pressure tends everywhere to a spherical form.

But if the pressure arose solely from the homogeneous particles of the ninth kind; and if there were an element within which could not be compressed; as, for example, in the case of spheres, or bladders filled with water, then the pressure would be found to give rise to other than a spherical form. But there is another reason. Since the interior particles of the fourth kind become less from compression, in agreement with the law of external pressure, then there can be no other internal pressure than that which is equal in all directions in the cavity of the

particle ; therefore the air is spherical in form, although it undergoes very forcible pressure externally.

146. THE SURFACE OF THE AIR PARTICLE IS MOVED INTERRUPTEDLY BY INTERIOR PARTICLES OF THE FOURTH KIND, BUT BY NEIGHBOURING PARTICLES MOST ADVANTAGEOUSLY ALONG THE EQUATOR ; AND IN THE AIR PARTICLE THERE IS A DOUBLE MOTION.

The enclosed particles of the fourth kind maintain a polar position ; for in them there are polar cones ; and these are kept continually in a direction toward the mundane pole. But we have said previously that in particles of the fourth kind that position is not so accurately observed, since with particles of the sixth kind they are in the same vortex and motion, consequently, they are able to move in a circle, but still they lapse into their own position. Hence included particles of the fourth kind preserve their polar position in every motion whatever, consequently they can be driven round about. But since the enclosed matter strives after the said position, therefore, when certain revolutions have been completed, they return to that position. But in the air particle, or that of the ninth kind, we have to consider a double motion. The first is that which is induced by the surface itself. For the surface can be in motion while the enclosed matter is quiescent ; because the motion of the surface of particles of the fourth kind acts upon the surface of a particle of the ninth kind, so that it is caused to move in a circular manner ; and it would seem also that this motion is likewise spiral, and proceeds along the path or fluxion of the matter in the surface of particles of the fourth kind which are enclosed therein ; for it follows perfectly the motion which the moving particles possess. But a second motion is possible, that of the surface itself together with the enclosed matter ; these being conjointly moved. For a particle is capable of exerting influence in a twofold way—the surface itself, when it is moved as a whole and also each particle can have its own motion ; in the same way as the earth itself moves

on its axis, while minute creatures and every kind of living thing move about on its surface. So, too, a ship is borne along on the ocean, while the sailors on board move about hither and thither. Similarly an air particle can revolve, and yet every particle in its surface can have its own motion, their motion appearing to be the same as the motion of the particles of the fourth kind contained in the surface, which is spiral.

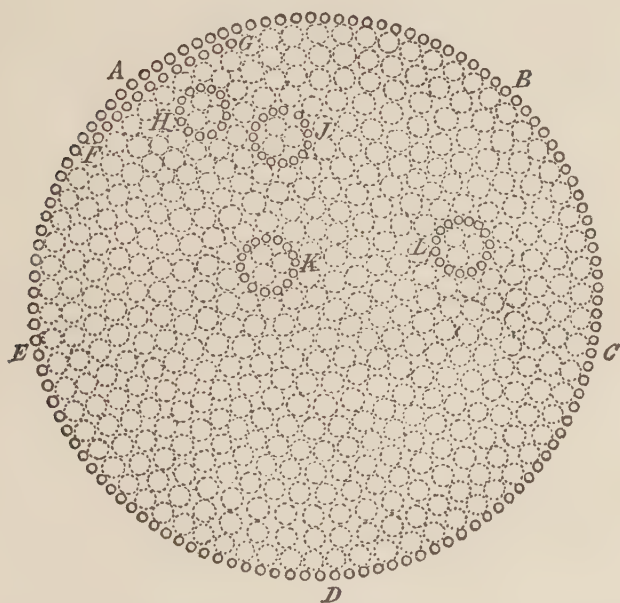
There is another motion of the whole particle, by which the enclosed particles also are moved, not, however, with different motion; hence according to what we have laid down the whole particle is moved circularly and in all directions, still it is most fittingly carried along the equatorial line or circle; for the particles of the fourth kind, both those within and those without, tend to a polar position, whence, when they circumgyrate along the equator, they have no need to strive to preserve their situation, but they remain, as it were, in a natural situation. For when the particles are turned in another direction, the enclosed particles of the fourth kind must necessarily be turned; also the more the motion departs from the equatorial circle, the more must the particles be subject to change of revolution. Hence the natural revolution of this particle is along the equinoctial. Nevertheless, the particles of the surface itself move according to a spiral gyration, of which we have frequently made mention.

147. IF A PARTICLE OF THE NINTH KIND SUFFERS COMPRESSION, THE COMPRESSED SURFACE FALLS TOWARD THE INTERIOR PARTS, AND, BY ENCLOSED MATTER OF THE FOURTH KIND, IT IS FORMED UP INTO NEW, BUT SMALL PARTICLES.

We have shown that a particle of the ninth kind or the air particle consists of a simple surface, and that it has particles of the fourth kind within and also without. But when this particle is subject to pressure, so that the surface falls toward the interior, that is, when the surface begins to be duplicated, then, I say, those particles of the surface which are forced toward the interior, become spheres of a less size under the influence of the enclosed matter. The reason for this is the same as in the

previous case. Those surface particles of the air particle, when they are under pressure in every direction from matter of the fourth kind, are then able to continue intact; for they receive as much pressure in one direction as in another; consequently, the surface rests in a state of equilibrium; and the surface particles, as if in their own natural state, move about the surface. But in truth, when any part of the surface falls

Fig. 94.



toward the interior parts, so that some surface particles are separated from their surface and, consequently, experience pressure from the enclosed matter, but not from the external matter, then that matter, or the enclosed matter of the fourth kind, acts upon them, just as it previously acted when the air particle was formed.

In order to have a better idea of this let us consider fig. 94. Let *ABCDE* be an air particle with the enclosed particles of the fourth kind. If the one undergoes compression so that the exterior surface is driven toward the interior, or folded as in

FG, then there is no pressure without ; so that the particles *FG*, which are carried towards the interior, have their equilibrium disturbed, or the pressure to which they were subject, consequently, the matter of the fourth kind acts upon them, because they are, as it were, in a free state, and they are, as a result, caused to assume the form of small particles, such as *H, J, K, L*. The reason for this has already been given—they lose their equilibrium, being relieved of pressure from every direction, when they come within the periphery, and are consequently rolled up into smaller particles, as *H, J, K, L*, which float, as it were, in the larger particle ; and by expansion and compression they maintain themselves in a kind of equilibrium. In these smaller particles the same matter is enclosed as in that of the particle of the fourth kind ; nor can they be diminished or become greater unless the matter enclosed in the air particle is dilated or compressed.

Here we see how the air particle can be restrained and compressed, and whither the surface matter betakes itself in compression. For the matter remains the same however much it is contracted, the weight of the volume being increased in that proportion. If there is considerable compression, a hundred or more particles may be formed, and the whole cavity filled by them. The reason is as just now stated, that such particles must be compressed both exteriorly and interiorly, and otherwise lose their equilibrium, these alone being unable to be present in particles of the fourth kind ; for the former have no motion, being small and heavy ; while the latter are exceedingly mobile, larger, and extremely light ; consequently they do not come together in one volume, unless they fall upon some surface, undergo pressure in every direction, and thus constitute a particle. This could also be shown geometrically if it were worth while.

148. THESE NEW ENCLOSED PARTICLES THAT HAVE ORIGINATED FROM SURFACE MATTER OF THE AIR PARTICLE, ARE CARRIED NOW TOWARD THE CENTRE, NOW NEAR THE SURFACE, ACCORDING TO ANOTHER MOTION OF THE AIR PARTICLE.

These new particles formed within the air particle are, indeed, in a state of equilibrium within the particle, nor do they tend upward or downward; for the pressure within is equal to that without in its first formation. If, therefore, the air particle were at rest and without motion (the surface particles can nevertheless be the subject of motion, the enclosed matter being quiescent), then they could neither fly to the centre nor, elsewhere, tend toward the lower parts; and when the air particle begins to be lightly moved, then they flow hither and thither, now to the centre now to the periphery. But when the air particles begin to be somewhat forcibly put in motion, and, in fact, along the equatorial circle, then, because these particles are somewhat heavier than the enclosed matter of the fourth kind, they are projected toward the surface, and there take up their own position. So that they are carried by a more forcible motion from the centre toward the surface, just as heavy bodies are when enclosed in a rapidly rotating cylinder.

149. WHEN THE AIR PARTICLE EXPANDS, THEN THESE ENCLOSED PARTICLES ALSO EXPAND AND ARE DISPERSED, AND RETURN TO THE EXPANDED SURFACE OF THE AIR. A PORTION OF THEM DOES NOT SUFFER DISPERSION UNLESS THE AIR PARTICLE IS DILATED TO THE AMOUNT OF PRESSURE TO WHICH THESE PARTICLES ARE SUBJECTED.

First, we have spoken above of the formation of the new particles contained in the air particles, that is, that they are formed when the surface matter is forced inward, and the particles are compelled to betake themselves into the cavity; for then such particles are not the subjects of equilibrating pressure; consequently, they are again rolled up into small particles of the kind described; and those have originated from the air itself. It follows,

therefore, that some such particles are formed when the air undergoes slight pressure. But the number of particles becomes still greater, the greater the pressure, and more still when the pressure is very greatly increased. For example, if the diameter of the air particle is ten units, then, if the pressure reduces it to nine units, new particles are immediately formed within the cavity. If the pressure still increases so that the diameter is eight units, further particles are produced, and still more if the pressure is continued, the diameter of the air particle becoming seven, six, five, four, or one unit.

These things being granted, it undoubtedly follows, that the enclosed matter of the fourth kind suffers pressure to the same extent as the air particle itself. For example, if the air particle is reduced from ten units to nine then the enclosed matter of the particle of the fourth kind alone undergoes pressure, that is, each particle of the fourth kind, or its diameter, is reduced by pressure from ten to nine units; so, too, if the air particle is compressed to eight, seven, six, five, four, three, two or one units, then also the diameters of the included particles of the fourth kind undergo pressure in the same proportion, so that the pressure of the enclosed matter of the fourth kind is the same as that of the air itself.

If, therefore, these new air particles within the air particle possess also the same matter as that of the particle of the fourth kind, as those which were formed in the first degree of compression, that is, when the diameter of ten units is reduced to nine units, then those that are formed under that pressure possess this enclosed matter, this being reduced, as to diameter, from ten to nine units. Moreover, those particles formed when the air is still more compressed, say to eight units, have then enclosed matter of the fourth kind compressed to the same extent, similarly those smaller particles which arise under still greater compression. So in one air particle there are many such particles which hold within them matter of the fourth kind differently compressed.

But, in fact, when the air particle is compressed, then the

matter enclosed in the air particle—I say nothing of the matter of the same kind enclosed in these new and small particles—throughout the whole cavity is subject to the same pressure ; and it exercises pressure upon the concave surface of the air particle, and also upon the convex surface of these new particles. If the pressure is greater without than within, then they are able to remain intact and unbroken ; but when the air undergoes expansion, then the matter of the fourth kind enclosed in the air particle is expanded, and, consequently, does not exercise an equal pressure upon the convex surface of these new particles ; but the matter enclosed in these new particles exercises an increasing pressure ; so that the equilibrium in them perishes and they consequently collapse, and recede to the dilated surface of the air particle. But they do not all collapse, but only those which are formed under the same pressure as that to which the air particle returns.

For example, let the air particles expand from one to two units, then all those new particles formed when the pressure was one unit are broken up. Or if the air particle has its diameter increased from eight units to nine, then all those small particles which were formed when the amount of pressure was eight units are dissolved. If the expansion still increases, say from nine units of diameter to ten units, then all those new particles are broken up which were formed when the force of compression of the air particle reduced the diameter of the air particles from ten to nine units. Or still more clearly, if the expansion of the air particle rises from one to six units then all those new particles are dissolved which were formed when the diameter of the air was reduced from six units to one unit ; but not those particles which come into existence when the compression of the air particle reduced the diameter from ten to six units ; these are first broken up when the particle has its diameter increased from six units to ten units by compression, and so forth.

Immediately those particles dissolve they recede to the surface of the air particle, and form a connection or series with them. Whence it follows that the more dilation takes place the more will

there always be an unbroken surface consisting of particles of the eighth kind. For as in the state of contraction a surface existed, so will it be in a state of expansion, the same amount of particles will find a place in the surface of the air particle when there is the same amplification ; whether in a state of contraction or in a state of expansion.

150. BECAUSE THE AIR EXERTS PRESSURE ACCORDING TO THE HEIGHT OF ITS COLUMN, THEREFORE ITS PARTICLES ARE MORE EXPANDED IN THE HIGHER PARTS OF THE ATMOSPHERE THAN IN THE LOWER. NEVERTHELESS, THE AIR PARTICLES MAY BE MUCH EXPANDED IN THE LOWER REGIONS OF THE ATMOSPHERE, AND YET A COLUMN IN THE UPPER REGIONS OF THE ATMOSPHERE MAY EXERT UPON THEM THE SAME PRESSURE AS THAT BY WHICH THE NEIGHBOURING PARTICLES ARE CONTRACTED BY GREAT PRESSURE ; AND THE CONTRARY.

The air particles are subject to a threefold force as previously stated, which they undergo from particles of the fourth kind, but that pressure can give rise to no contraction ; for the particle suffers the same pressure from the same matter within as without, so that equilibrium is maintained, unless, therefore, other matter is added, from which it may undergo pressure, I hardly know whether they could subsist. Hence the pressure is exerted by another force from the matter of the particle of the seventh kind ; and by a third force arising from the homogeneous particles of the air, so that they undergo pressure according to the height of the column. This can, in fact, be proved mechanically and by the help of considerable explanation, but it would be superfluous to discuss these matters, since there is no difficulty in demonstrating them ; besides, we must defer this matter until we have proved that the pressure is proportional to the altitude in every direction, and also proportional to the base and opening ; and there are many things which can be made clear by experiments which we shall put off for special consideration.

It is clear from these things, that the particles in the surface of the atmosphere are very much expanded, so that the diameter of one air particle there measures many units ; and it can be shown that the diameter of a particle there is hundreds of times greater than the diameter of an air particle near the earth ; but this fact must be proved by experiments.

But in the atmosphere near our earth air particles can be expanded by a certain force, and yet undergo pressure from those above them just as if they were not expanded. For if particles of the fourth kind, which are external, are moved or urged into motion, so that they undergo expansion, it follows as a consequence that their state of equilibrium is changed, and that the enclosed matter of the same particle of the fourth kind also becomes expanded, and carries with itself in that process of expansion an air particle, or that of the ninth kind.

If, for example, enclosed matter of the fourth kind suffers greater compression than that which exerts pressure exteriorly ; and if the latter is expanded, then it follows that the enclosed matter undergoes expansion, and together with that the surface of the particle of the ninth kind, although the particle of the ninth kind supports pressure from the particles that rest upon it just as if it were not expanded. Also we must add, that particles of the ninth kind may be driven into very rapid motion, and, consequently, may force all the enclosed matter with those newly-formed particles to the periphery, and expand it by a certain force. Hence we see that a particle of the ninth kind can be expanded not only in the surface, but in the centre, or in the lowest part of its column. But as the cause is different, therefore, the effect arising therefrom is different. Of these things we must treat in our theory experimentally and in dealing with special subjects.

151. IF A PARTICLE OF THE NINTH KIND IS TOO GREATLY EXPANDED, ITS SURFACE MAY BE DISRUPTED ; BUT THE SURFACE MATTER SET FREE AND DISRUPTED WILL PASS INTO THE SURFACES OF OTHER PARTICLES OF THE SAME KIND.

If a particle of the ninth kind be too much distended, whether in the highest region of the atmosphere, where there is no pressure from particles acting from above, or even in the lowest region from other causes of which we have spoken in the previous pages, it will happen that there will be a defect of the surface matter, so that the surface will not be continuous. Consequently, it follows that the enclosed matter of a particle of the fourth kind will be able to burst forth through the interstices, or otherwise, since the pressure outside is not sufficient to counteract the interior pressure, it will be unable to be kept in the regular surface ; consequently, such a particle will be broken up, and as it were, vanish completely. Hence this surface matter or that of the eighth kind will be dissipated, and will only be able to find a place in the surface of lower particles, which surface it will increase ; so that a heavier particle will exist and have a greater amount of surface material, which will fall toward the interior parts, and form the new particles, of which mention has already been made. Again, such a particle can be more expanded than that which has collapsed, and of which we have spoken, so that it can be expanded to such an extent as to be hardly capable being of broken up.

It is clear from these things that particles in the highest region of the atmosphere are capable of being distended, so that their diameter may be greater than the diameter of a particle of the same kind in the lowest region by hundreds or thousands of times. For it is evident that such a particle is increased by much matter through the collapse of other particles in the neighbourhood, in which there was not so great an abundance of matter. A particle, therefore, in the highest region, hundreds or thousands of times greater, may have ten times

more matter than a particle in the middle or lowest region of the same atmosphere.

It follows, therefore, that by such disruptions and collapse particles may be formed which can be no further broken up by any amount of expansion; for in them there is a sufficiency of matter to form a bar to any disruption.

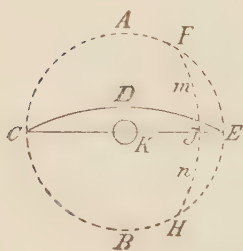
152. THERE MAY BE PARTICLES OF THE NINTH KIND IN THE MIDDLE AND LOWEST REGION WHICH DIFFER BOTH IN WEIGHT AND SIZE; BUT STILL, AFTER AN INTERVAL, THEY MAY GRADUALLY BECOME EQUAL IN BOTH WEIGHT AND SIZE.

Since, now, particles of the ninth kind may be broken up by too great an expansion, and since such expansion may take place not only in the highest region, but also in the middle and lowest regions of the atmosphere, therefore the surface matter may betake itself to other particles in the vicinity, and augment their surface. Their weight will, consequently, be increased; so that the weight of some particles will be greater than that of others; and there will be certain differences between the particles. Since, however, some are heavier, they cannot be aptly moved with other particles in their vicinity, but are driven to another part, being thus separated from others to which they are dissimilar. In the same way it will happen that one particle will be larger than another, either because one is more expanded than another, or because there is within a greater abundance of matter belonging to particles of the fourth kind. But since the motion of one particle does not entirely synchronise with the motion of the rest, therefore, after an interval they will be driven thence; for both the pressure and the motion itself offer an impediment; consequently, anything so dissimilar to, and out of harmony with, the rest will be driven thence, nor could they continue for any length of time to exist together in one volume. Equality of the motion itself acts in such a way that such a particle will be thrust either up or down, and the volume deprived of it.

153. INEQUALITY OF FORM IN THE TELLURIAN VORTEX, ARISING FROM UNEQUAL PRESSURE OF THE CIRCUMFLUENT MATTER, GIVES RISE TO INEQUALITY OF THE MOON'S MOTION, THE EBB AND FLOW OF THE SEA, AND ALSO TO VARIOUS STATES OF THE AIR AND ITS STORMS.

Much variety exists among particles of the ninth kind; sometimes they are less and sometimes more compressed; whence the volume of their particles is sometimes heavier, sometimes lighter; and aqueous vapours arise according to the weight or lightness. But if we consider the form of the tellurian vortex, we shall see that many things may be deduced which give rise to variety in the volume of particles of the ninth kind. As to the form itself, it is not exactly spherical, but because that vortex is borne in the great solar vortex, it is carried round, in a kind of stream as it were. For it is well known that the great solar vortex is carried round along the ecliptic, and that the whole vortex is carried round in that direction—the vortices of the planets too are borne on such a stream; but since they are separated from the matter of the great vortex, so that such vortices as are fluent in the greater vortex are distinct both in motion and matter, as we have before shown, therefore they do not follow the stream of the greater vortex by their own fluxion, but they are compelled to follow the stream, just

Fig. 95.



as a ship, forced to move in a certain current, follows the current, but there is a continual action against the stern or back of the ship; so, too, the vortex of the earth moves indeed in that vast current, but yet this stream acts continually on one part.

In fig. 95, let $AEHBC$ be the earth's vortex, CDE the ecliptic, EKE the equator; let the stream act continually against the side of the vortex at E . Because the pressure is there, therefore also the vortex will alter its form, nor will it be any longer exactly

spherical. On that side it will become flatter, as FJH , so that the diameter of the vortex on the side toward the earth K , that is, JK , will be less than on the other side CK . Since, therefore, it is evident that the form of the vortex is not everywhere spherical, but flatter on one side, it follows that there is great variety in the volume of particles of the ninth kind. We will here enumerate briefly the various classes :—

1. In spring and autumn the vortex undergoes pressure in its middle part. That is, the greatest pressure then exists around the equator, as is evident from the figure, and, consequently, it is less at a more remote distance from the equator. The reason of this is that the ecliptic then cuts the equator ; or one point of the ecliptic is on the equator.

2. In spring there is the greatest pressure at a distance of $23\frac{1}{2}$ degrees from the equator, and it is above, and, consequently, exercised equally towards the ecliptic poles. Hence in summer the pressure varies according to its distance from the equator. It differs also, in respect to the inhabitants, from spring and autumn pressure.

3. In winter the pressure is greatest at $23\frac{1}{2}$ degrees from the equator, so that the vortex experiences the greatest pressure when it is at the stated distance of $23\frac{1}{2}$ degrees below the equator ; consequently, it follows that the pressure then is less above the equator than at any other time of the year, and therefore the pressure will vary in respect to the inhabitants of the earth.

4. The moon which, together with its own vortex is borne along in the earth's vortex has its own motion and follows the stream of this vortex. As seen by us it seems to pursue its course unequally, for at one time it is in perigee and at another in apogee, at another time at a middle distance. The cause of this is, that when the moon is at quadrature, as in J , then it is nearer the earth than when at C and consequently in perigee, and differently when in apogee. The perigee also differs according to the times when it arrives there. For if the moon were distant from the equator to the extent of $23\frac{1}{2}$ degrees, so as to be then in the lowest or highest part of the ecliptic, the apogee would

be less than if it were near the nodes, or near the equator. For, unless the altitude of the moon from the equator when at quadrature were observed, it would be impossible to determine the apogee. But when the moon is new or full, then the moon is carried along very uniformly or equably.

5. Since, therefore, the moon is carried along unequally when in its quarters, that inequality will be found to be increased when the time of the year has to be considered ; that is, whether it is summer, winter, or autumn. Then, too, in respect to the moon, another distance at once comes into consideration. For example, in winter, when the pressure is greatest at a distance of $23\frac{1}{2}$ degrees under the equator, let the moon, at the same time, be at its greatest altitude, or $23\frac{1}{2}$ degrees distance above the equator ; whence at 47 degrees the moon is removed from the maximum pressure of the vortex, and consequently is in its perigee. But because it is so far removed from the maximum pressure, its perigee is not so exact, because here the moon proceeds as though it were not in its perigee. But if the moon were in winter under the equator at $23\frac{1}{2}$ degrees, then it would be in its maximum perigee.

6. What is here said of perigee must also be understood of apogee, which is in the other or opposite position. For the pressure in this direction is proportionately extended to other parts. But since the matter of the vortex does not go wholly to the opposite place, but also proceeds laterally, therefore the moon's apogee does not withdraw in the same proportion as its perigee approaches.

If, then, the figure of the earth's vortex were examined, and compared with the pressure of the large vortex, then our knowledge of the moon's motions would become easy, this knowledge offering such difficulties in calculation, that the place of the moon by observation and calculation is scarcely obtainable when it is at quadrature. Let it be considered at full and new moon ; for there it is at a middle distance from the earth, then the matter is easy, its motion at that period being equable.

But because the cause of apogee and perigee is not yet known, it must be deduced from observations ; so that there may be error in its determination. We see here what the true cause is, why perigee varies at different times, so that we can scarcely declare that it is in perigee, when nevertheless it is. Another time it is in its greatest perigee or apogee. If these things are rightly weighed, the moon's motions can be easily explained. But because it is not our purpose to describe the moon and its course, but simply to investigate the form of the elementary particles ; and because the quality of the particles much depends on this—which will be seen in the following pages—therefore I can simply give a general idea of this matter, otherwise I might develop the conception and geometry of these matters more fully.

In regard to the ebb and flow of the ocean, this is thought to arise from the moon's pressure, and this opinion is held, since it coincides with the motion itself of the moon. But if we went into the real origin and cause of this phenomenon, we should see that the true cause is to be found in the inequality of the vortex ; for when the form of the vortex is irregular then there is inequality of pressure. Matter of the sixth and seventh kind exercises pressure according to the altitude of the vortex. Hence, when the vortex is higher in one part than in another, at a time when the moon is at its quadrature and in perigee, the flow of the tide will be least ; for the pressure is least there ; also the altitude is least, as *JK*, fig. 95 ; but at another place the pressure is greater and the altitude greater ; but these vary according to the moon's position. When the moon is at *JK*, being then endowed with a definite vortex, it occupies a certain position, and, consequently, increases the height of its vortex in that part, and when this happens there is greater pressure in that direction ; whence the pressure exercised by the moon alternates and varies. The real cause is in the altitude of the vortex, which is less on one side than on the other.

The reason why the air undergoes a certain alteration through the inequality of the vortex is this. The pressure exercised by

matter of the sixth and seventh kinds is less in one place than in another. The less the altitude the less the pressure, and the contrary; therefore the pressure is less in one place than in another; consequently, the pressure varies. This pressure is not exerted on the volume of particles of the ninth kind, or on the atmosphere itself, but on each particle of the ninth kind. For the air, or a particle of the ninth kind, undergoes pressure from particles of the sixth and seventh kind, hence that pressure is exercised upon every particle of the ninth kind, or the air particle. When, then, the air, or each particle of the air, is under pressure, it follows that each particle of the air undergoes pressure, and, consequently, becomes less; and thus the volume becomes heavier as the particles become less.

If, then, the altitude of the vortex is great, considerable pressure and contraction of the air particles result; but where the altitude is less, then there is less pressure, and a certain expansion of the particles results. But here the moon intervenes. For if the moon is moving in its perigee the vortex in that direction immediately becomes higher, and, consequently, there is a greater pressure of the particles than if the moon were away; and still greater if the moon were in apogee. This pressure of the particles of the ninth kind also varies according to the time of the year. In spring and autumn the altitude is least near the equator, and greater laterally. In summer the greatest pressure is at $23\frac{1}{2}$ degrees distance from the equator towards the north; in winter the pressure is greatest at $23\frac{1}{2}$ degrees distance from the equator toward the south; hence the pressure of the particles varies in different regions.

There are various reasons for the changes in the weather. *First*, there is the diverse form of the earth's vortex, whence there arises a diversity of altitude, and a diversity of pressure of the particles of the sixth and seventh kinds, which exert a pressure individually on every particle of the ninth kind or the air particle; for they do not exert pressure on their volume, but separately.

Secondly, the moon increases its column in the vortex wher-

ever it comes, whence the vortex undergoes a variation in respect to the moon.

Thirdly, the altitude of the vortex in autumn and spring, is different from what it is in summer and winter.

Fourthly, there is one pressure of the moon in apogee or in perigee, another also if the moon is at its greatest altitude from the equator or elsewhere. This variety depends much on the compression of the particles of the ninth kind and their expansion.

For if the column of the earth's vortex is higher, then the particles of the sixth and seventh kinds will be subject to greater pressure, and, consequently, will become smaller; the particles of the ninth kind will be compressed as a result, so that they too will become smaller. This variety gives rise to variety in the weather, so that it is now rainy, now calm; now the mercury rises, and now falls; and many other phenomena besides.

We must not indeed omit to remark that the sun by its rays and motion contributes much to variety in the weather. For when the motion springs up in particles of the fourth kind, then the particle of the ninth kind undergoes expansion, and thus the sun may act contrary to the vortex. There is some action also arising from the reflected light of the moon, but it is slight.

If these causes are well understood, I trust that the weather phenomena may be able to be investigated, and the reasons for the rise and fall of the barometer may be able to be explored; as also some of those evidences which appeal to our senses, or are afforded by chemical experiments, or that are seen in the constitution of our bodies. There are many other matters which I feel must be passed by now.

154. THE PARTICLES OF THE NINTH KIND ARE SUBJECT TO
AN UNDULATORY PRESSURE JUST AS ARE THE PARTICLES
OF THE SIXTH AND SEVENTH KIND.

If the origin and source of undulation is in the volume of particles of the ninth kind, then no other undulation exists

around the particles of the sixth and seventh kinds than that which has already been considered. An undulation begins if some nerve or some other vibrating body is subject to movement; or if a vibrating sound proceeds from the throat of some animal, or arises in some other way, then the source of the undulation sets the particles in movement, so that they end in a certain pressure. This pressure, acting on some membrane that is suited for receiving the vibration, immediately causes the membrane to vibrate in a manner corresponding to the undulation in the source itself. It is in this way that the undulation of the membrane in the ear gives rise to an undulation in the nerves, this being communicated by means of the enclosed mechanism.

The same kind of undulation and pressure may be observed in particles of the ninth kind as in particles of the sixth and seventh kinds with no other difference than that the vibratory motion is slower, because the particles are heavier.

155. THE GREATER THE PRESSURE EXERTED ON PARTICLES OF THE NINTH KIND THE GREATER THE DIFFICULTY OF VIBRATING.

The more particles are pressed, the less do they become, and, consequently, the denser is their volume; hence, the heavier each particle is and, consequently, the less adapted to motion, the slower is the motion, and, consequently, the pressure is greater and more effective. Also the volume becomes denser and the undulation consists of greater volumes. But because the undulatory motion is slower as a result of weight, therefore, such sound is perceived in the organs of hearing as a lower pitch.

156. THE PARTICLES OF THE NINTH KIND POSSESS CONSIDERABLE ELASTICITY, AND ALSO APTITUDE FOR VIBRATION.

That particles of the ninth kind possess elasticity is clear from this, that they enclose matter of the fourth kind, which is very sensitive to external pressure and expands and contracts accordingly. Hence, as soon as a particle of the ninth kind comes under

the impact of another particle, the surface yields ; and it does so, because the enclosed matter gives way. I do not think there is a more elastic particle, for no other particle has matter of so yielding a quality. Consequently, there is the greatest amount of reaction in particles of the ninth kind. That there is also vibration follows as a matter of course, for when a yielding surface suffers impact it immediately recovers itself and then an undulation arises in the surface which is communicated to the enclosed matter. But the nature of vibration in elementary particles will be better seen in the following paragraph.

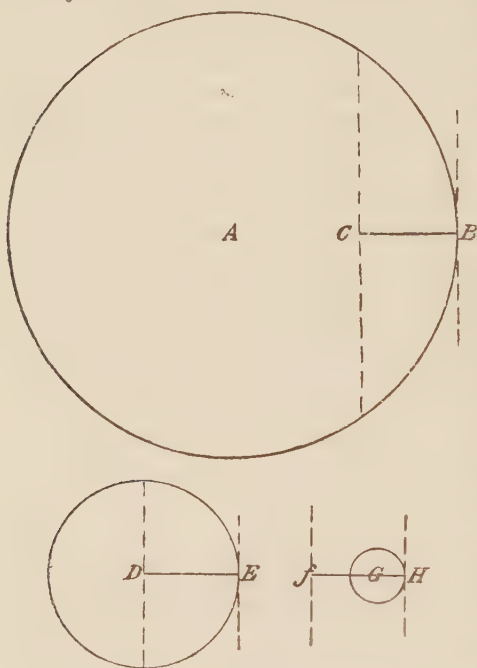
157. A SMALL VIBRATION IN PARTICLES OF THE NINTH KIND SETS UP A CERTAIN BUT MINUTE VIBRATION IN PARTICLES OF THE SIXTH AND SEVENTH KINDS, ALSO A CONSIDERABLE VIBRATION IN PARTICLES OF THE THIRD AND FOURTH KINDS, AND THE CONTRARY.

The diameters and dimensions of particles of the ninth, sixth, seventh, third or fourth kinds, differ very considerably. Consequently a particle of the fourth kind may be said to be very small compared with a particle of the ninth kind. Whence, since a particle of the ninth kind must be considered as a definite mass in comparison with a particle of the fourth kind, it necessarily results that when the larger particle or that of the ninth kind vibrates, that is, when its surface is set vibrating, it will undulate less than a particle of the seventh kind, and a particle of the fourth kind will undulate most, or be moved from place to place.

For an undulation is a reciprocal motion of the particle together with its own centre, while a vibration is the motion of the surface without the motion of the centre. So the more the centre is moved the greater is the undulation. Hence when a small particle is moved, although it is not moved more than a larger particle, still the motion is greater in the small than in the large particle. As for example, if, in fig. 96, *A* were a particle of the ninth kind, although in comparison with a particle of the seventh and fourth kinds it is of considerable size, still,

if the surface were in a state of vibration, so that the movement is from *B* to *C*, if, in the return movement, it touched the particle

Fig. 96.



D, then the latter would move from *D* to *E*, that is, to the distance of the semidiameter of that particle. But if by the same impact *G* were moved, then this would be moved from *f* to *H*, so that it would describe a double path, or the length of its own diameter, consequently the undulation in the small particle *G* is considerable, when there is any vibration in the larger particle *A*. Still it is not yet clear to me whether the vibration in a hollow sphere

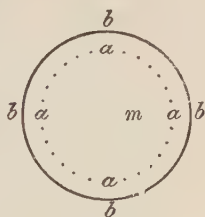
is the same as in these elementary particles, or whether the whole surface undergoes contraction at the same time, or only part of it. It is indeed true that if a particle vibrates, the enclosed matter suffers compression to the same amount. Hence if the enclosed matter is compressed, and the compression is the same in every direction, then it follows that, as a result of the vibration, there will be a very rapid contraction and expansion of the particle. As for example, if in fig. 97, the sphere be struck at *b* so that the surface bends inwards to *m*, then I suppose, that in place of a certain vibration in a part only of the surface, the sphere will vibrate as a whole, that is, the particle will become smaller, that is to say, it will be represented by *aaaa*, and then quickly return to *bbbb*, and so continue its vibration. Suppose the elementary particles to vibrate in

this way, still it follows that vibration in the larger particle will set up undulation in the smaller ; for if the vibration be greater than half the semidiameter, the particle itself will certainly yield, and undergo change of place in an undulatory way.

When, therefore, such a vibration is set up in the surface, it is also set up in the matter enclosed in the particle of the fourth kind, so that there is a like reciprocation of motion.

On the other hand, when particles of the fourth kind undulate, and such undulation is considerable, then it sets up a certain small undulation in particles of the seventh kind, and the said vibration in particles of the ninth kind, and, on the contrary, as previously stated.

Fig. 97.



158. UNDULATORY PRESSURE OF PARTICLES OF THE NINTH KIND IS REFLECTED.

Reflection takes place in this undulatory pressure in the same way as in matter of the seventh kind, such reflection striking directly on the ear or its membrane. For particles are almost of the same kind, with the difference only that exists between what is greater and less, between heavier and lighter. But the auditory membrane is such that it does not so distinctly perceive all those degrees and modifications which the eye is capable of in matter of the seventh kind.

159. REFRACTION ALSO TAKES PLACE AMONG THESE PARTICLES OF THE NINTH KIND, BUT IT CAN RARELY BE OBSERVED.

Since there is such a similarity among particles, and since difference consists only in dimension, in addition to something which does not cause much difference, it is consequently true that refraction also takes place. But as such objects by which the truth can be explored are rare, therefore we may conclude from similarity that there is refraction in this undulatory pressure ; that is to say, sound can be increased or diminished when it passes from one medium into another and be refracted on the way by reason of the particles.

Here also we may rightly treat of the pressure of such particles as takes place in proportion to the altitude, opening and area. The pressure is equal in all directions, laterally, above and below. But because the same things occur in the behaviour of a particle of the tenth kind, or water, therefore we must treat of the mechanical and natural qualities of that particle in our description of it.

160. IF A PARTICLE OF THE NINTH KIND BE SO COMPRESSED THAT THE GREATER PART OF ITS SURFACE IS TRANSFORMED INTO SMALL ENCLOSED PARTICLES, SO THAT THE ENCLOSED MATTER OF THE FOURTH KIND IS FOR THE MOST PART TAKEN POSSESSION OF BY THESE, THEN A NEW PARTICLE WILL COME INTO EXISTENCE, WHICH IS DESIGNATED A PARTICLE OF THE TENTH KIND ; THIS IS THE WATER PARTICLE.

Before it can be understood how the particle of the ninth kind can be compressed into a new particle, those things should be read which we have previously set forth concerning the compression of particles of the ninth kind and the method of their compression. For we stated that when these undergo compression, parts of the surface are transformed into new and smaller particles, which pass into the cavity of the particle and there float about among particles of the fourth kind ; while the matter which is without expands and, consequently, the enclosed matter, in establishing equilibrium, also undergoes expansion ; and then these new particles, or the offspring of the delicate air particle, are set free.

Since these particles of the ninth kind can be so compressed, that the whole enclosed matter of the fourth kind is absorbed by the new particles, hardly any or little of it remaining, it follows, therefore, that there is nothing within which is capable of expanding such a particle, but that it is kept closed, as it were. For matter of the fourth kind is enclosed, which expands the air particle ; but when this is absorbed, and is intermingled with new and smaller particles, little of such matter remains, and so little that the surface can no longer be enlarged or expanded

by it. And unless this takes place, a new particle comes into existence which is called a particle of the tenth kind ; this is the water particle itself.

The nature of this compression, and how it could exist in the beginning of things, may be gathered from the following. The height of the atmosphere, according to some theories, would seem to be several miles. The atmosphere exercises pressure upon itself, so that the higher particles press upon the lower ; consequently, in the lowest region the pressure is very great. But in the beginning of things, as stated, the atmosphere, or particles of the ninth kind, could extend even to the centre of the earth, and consequently had an altitude of from 500 to 600 Swedish miles,¹ equivalent to a semidiameter of the earth. Hence, since the atmosphere exercises a pressure proportionate to the altitude, and since the altitude would be equal to such a number of miles, the compression would be the greatest possible. For if the compression is so great with the altitude of the atmosphere at the present time, what must it have been when the height was 500 or 600 miles ? Consequently, the air particle must have undergone such pressure that the whole of the matter of the fourth kind around those new particles, and that enclosed in them, must have been consumed ; so that no more would have remained in the neighbourhood of these new particles to expand the adjacent surface. Here, then, you have the origin of such particles, and the history of the primitive state of compression, and of the birth of the particles of the tenth kind, or the water particle.

161. THE PARTICLES WHICH ARE ENCLOSED IN THIS PARTICLE OF THE TENTH KIND ARE VARIOUSLY EXPANDED BY THE MATTER OF THE FOURTH KIND ; AND ALSO THE NEARER THEY ARE TO THE CENTRE, THE MORE ARE THEY COMPRESSED, AND THE CONTRARY.

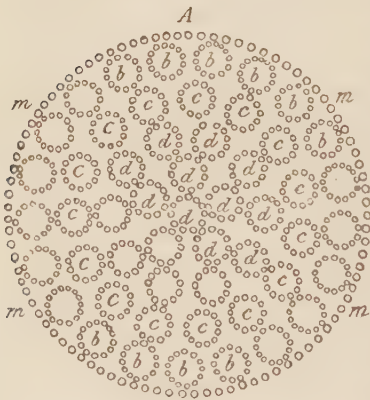
We have already seen what is the origin of the particles of the tenth kind ; that is, the surface of the particle of the ninth

¹ A Swedish mile is equal to 11,700 yards.

kind, under compression, betakes itself to the interior, and there, by means of enclosed matter of the fourth kind, is formed into new and smaller particles. Since, therefore, there exists such great compression that almost the whole of the matter of the fourth kind is absorbed by these, then there is nothing to reach within and cause the matter to undergo further expansion. These new particles formed in this way could not be formed in a moment, but gradually and according to the amount of compression. Hence in the first state of compression such newly formed particles are not subject to expansion, nor those which were subsequently produced, whence the diversity of compression in the case of these new particles; and the nearer they are to the centre the more compressed are they.

In fig. 98, let *A* be a particle of the tenth kind or the water particle; the enclosed particles are those which are formed by

Fig. 98.



the pressure of particles of the ninth kind. When, then, a particle undergoes such pressure, that no more matter of the fourth kind remains, but is absorbed by these new particles—for in them there is enclosed matter of the fourth kind—then it can undergo no further compression and expansion. For residuary particles of the fourth kind are concealed in the

interstices of these particles, or between these particles, and since they are few in number, therefore they cannot exercise any force either on these new particles, or on their surface, consequently they are completely dispersed on account of their fewness.

When, therefore, the particle of the ninth kind is compressed, then, in the primary state of compression, the surface particles become new particles, as we have previously stated; but the

matter of the fourth kind enclosed in them does not suffer much compression; for the compression of the matter of the fourth kind is almost the same within and without; hence in the first compression particles are formed which are not much compressed.

These new particles, if the surface is moved, place themselves near the surface; for there is a kind of centrifugal tendency in a moving particle of the ninth kind; consequently, these newly-formed particles take up a position near the surface. When the particle of the ninth kind, or the air particle, is subsequently still further compressed, again a part of the surface goes toward the interior, and so passes the nearer particles, which betake themselves nearer to the centre; whence particles of the same kind are formed, but are more compressed; and at the centre the compression is at a maximum.

For example, the particles *bbbb* are formed in the primary state of compression, consequently they have matter of the fourth kind enclosed within them not very greatly compressed. Still more compressed are *cccc*, and have enclosed in them matter of the fourth kind still more compressed, while in the particles *dddd* the compression is greatest, and so the matter seems to be composed of particles of the tenth kind.

From these things it follows that those particles that lie near the surface cannot, of themselves, be broken up, because the matter of the fourth kind, which is still fluent within these particles as a residue, is in a very high state of compression. Hence, when the matter flowing around becomes still more compressed than the enclosed matter, it follows, as a result, that it cannot be broken up. Nor can the surface *mmm* be expanded, for so small an amount of the matter of the fourth kind lies enclosed within as residue, that it can exercise, as it were, no force; and the abundance of such particles gives rise to the possibility of expansion.

Thus you have a description of the particle of the tenth kind. Still one thing remains, that such particles seem to be too large to be formed from particles of the ninth kind, such as are found

to-day in our atmosphere. There is not much difference in magnitude, but there is a great difference in weight. But one may reply to this, that when these particles were created, the particles of the ninth kind seemed to have been larger. For when the vortex of our earth was not far removed from the sun, and in the course of time went further off, these particles of the third or fourth kind, according to our theory, were evidently extremely large; for particles of the fourth kind are larger near the sun than at a distance therefrom. These undergo pressure in proportion to their altitude; hence the nearer the matter of the vortex is to the sun, the more dilated are the particles of the fourth kind. Since, therefore, our vortex was near the sun, before it was carried therefrom to the periphery or circles of the vortex equilibrating with the circumfluent matter, it consequently, would not be wonderful, if at that time the particles of the ninth kind were larger than they are to-day, being now in the circle where the matter of the fourth kind is more compressed. Consequently, the surface matter or that of the eighth kind was in greater abundance, so that such particles of the tenth kind could have been formed, these particles differing not much in magnitude, but greatly in weight. For such particles of the ninth kind were pretty nearly capable of existing in the surface, or in the extreme part of the atmosphere.

162. PARTICLES OF THE TENTH KIND CANNOT BE FURTHER COMPRESSED.

This is clear from what precedes; for there is no more residuary matter of the fourth kind, by whose help new particles could be formed, which would be, as it were, the offspring of particles of the ninth kind. Further, there is no more room for particles of this kind. Hence it follows that they could be no further compressed, except by the greatest possible weight, and in the profoundest depths of the sea. But we shall speak of these in our theory of salts and metals.

163. DURING THIS PERIOD OF THE CREATION OF PARTICLES THE EARTH WOULD SEEM TO HAVE BEEN NOTHING BUT OCEAN. SUBSEQUENTLY, HOWEVER, AFTER VARIOUS CHANGES, DISSOLUTIONS, MOVEMENTS, AND COMPRESSIONS OF PARTICLES, A DEFINITE SUBSTRATUM CAME INTO EXISTENCE, AND THE WATERS OF THE OCEAN BECAME PARTIALLY ENCRUSTED.

Hitherto it has not been our intention to lay down a theory in regard to the beginning of solids, that is of salts, rocks, earths and metals ; for it seemed to us a matter too deep for investigation, a work too great and extensive. It is sufficient to say that all those solids which have ever been found in our earth derived their origin from the fluid particles, whose description has been given in the preceding pages. Nature seems to have brought into existence nothing but fluids and elementary particles. And we have shown that a particle of one kind was created from another up to the particle of the tenth kind. This particle, again, may be broken up by various causes and take on other figures and forms ; and as a result a new particle immediately arises, which possesses neither motion nor any elementary quality ; and which may, therefore, be designated a solid. A solid particle comes into existence when motion ceases among equal particles. But since elementary particles are spherical, they cannot but move among one another, and by the help of motion all elementary qualities exist and are made evident.

Hence we come naturally to particles of the tenth kind which we stated were produced from compressed particles of the ninth kind near the centre of the earth. Consequently, it follows that this central state consisted of no other matter in the beginning of creation than these particles of the tenth kind ; and, consequently, the earth was a kind of ocean, so that in primeval times there was nothing but ocean. But that these particles of the tenth kind subsequently became more solid and also others of which it seems clear that the crust of the earth and the terraqueous globe consisted, must be shown below when we

treat of saline, rocky, and metallic particles, which require an extended and sound theoretical treatment.

164. AS A RESULT OF THEIR INACTIVITY AND OF THE EXCESSIVE PRESSURE TO WHICH THEY ARE SUBJECT, PARTICLES OF THE TENTH KIND MAY BE BROKEN UP.

Particles of the tenth kind are held together and their texture is preserved by means of circumfluent matter of the seventh kind, and by the motion of the particles ; for since particles of the seventh and fourth kinds flow round and thus exert pressure upon the cavity of the particle, and since there is only a slight pressure within, to which that small quantity of enclosed particles of the fourth kind gives rise, therefore they are bound to be maintained intact. But, in fact, if there is considerable want of movement, so that a kind of stagnation exists between the particles, then they are not subject so equally to pressure in every direction from the matter of the seventh kind, which equality of pressure also arises from the motion of a particle—which has been shown elsewhere—hence particles of the fourth and seventh kinds that are exterior and exert pressure on the convex surface of the particle may be gradually expanded or rarefied between the said particles. Hence that small quantity of enclosed matter of the fourth kind obtains a preponderance, and breaks up the external surface of the particle. Consequently, the new enclosed particles immediately, in turn, slip out ; for matter of the fourth kind is able to penetrate between them. But they are forced still further to the outside by particles of the seventh kind ; consequently, they cannot so easily pass out, except by means of a certain amount of motion and compression.

We have just shown that as a result of inactivity such particles of the tenth kind may be broken up ; also it could be shown that this disruption may result from great pressure such as exists in the deepest parts of the sea. For if the depth of the ocean at the first creation extended to the centre of the earth, there would then have been a pressure exerted equal to that of

five or six hundred miles of ocean, that is, a pressure proportionate to the altitude ; consequently, there would be the utmost pressure or weight. When, therefore, particles are subject to very great pressure, I am inclined to think that that structure of a particle which consists of so many enclosed smaller particles, all hollow and not mutually cohering, could not be prevented from being reduced to some other form by pressure, and lose their sphericity.

For if that structure be considered, it seems to be such as to be capable of being disturbed by very great pressure, and reduced to another form. For so many small particles, not cohering very firmly together, and of spherical form, should be capable of being altered by a certain strong pressure. And since the greatest pressure is in a deep sea, it would seem that such a particle must undergo dissolution. But the disruption of such particles and their character must be more fully treated elsewhere.

When, therefore, a particle of the tenth kind is broken up, whether this has been done at the bottom of the deepest sea, or at the surface, when particles are inactive, as it were, those which are enclosed slip out. Those which were nearest to the surface, and also those which were near the centre, may easily undergo dissolution subsequently ; especially if they are separated from those in the vicinity. But that break up takes place with a difference. For those which were nearest to the centre, are able to be broken up with the greatest ease, the matter of the fourth kind enclosed in them being very greatly compressed. Hence, when there is greater pressure within than without, it naturally follows that they are very easily broken up, so that I consider that they are disrupted with a certain amount of violence when once dissolution has taken place. But those that lie nearest to the surface are not so easily broken up ; for the pressure of the enclosed matter and that without, is almost equal, so that the nexus is not so easily destroyed ; and if it does happen, it would seem to take place quietly.

The matter set free, which is that of the eighth kind, can pass in the interstices between the particles, or if much matter of the

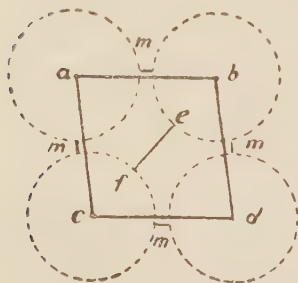
fourth kind is circumfluent, and if at the same time there is space, it may become again a new particle of the ninth kind. But of these dissolutions and metamorphoses of particles we must speak elsewhere, when we shall try to deal with the structure and forms of salts and metals. In the meantime we must show, casually, that such particles are capable of being broken up, in order that some little knowledge of these particles may be had.

165. THE ARRANGEMENT OF ELEMENTARY PARTICLES, AS ALSO THAT OF PARTICLES OF THE TENTH KIND, IS SUCH THAT ONE PARTICLE IS ABLE TO PASS THROUGH THE INTERSTICE EXISTING BETWEEN FOUR OTHER PARTICLES, ABOVE, BELOW, AND Laterally, AND TO BE THE SUBJECT OF MOVEMENT INTERMITTENTLY.

Since we have seen that all elementary particles are spherical and extremely mobile, therefore, it is necessary to have a knowledge of the arrangement of such particles—that they are sensitive to movement, and can pass from one place to another; and many other features besides. Therefore there can be no other arrangement among particles than this, that one rests upon four others in a lower position, that one undergoes pressure from four higher ones, and so forth; then one particle can be the subject of motion with all the rest, and one can pass through

the interspace between four others, whether this is above, below, or lateral.

Fig. 99.



As to the space which the matter of the fourth and seventh kind occupies, this must be submitted to calculation, and as the calculation would seem to be somewhat tedious, it is sufficient here to adduce the results of a calculation without the details.

For example, when the particles are in a position which may be called natural, then the space which the particles occupy in relation to the intervening or interstitial space is almost as

5 to 1 ; or otherwise, the filled space is to the empty space as 5 to 1. The interval m (fig. 99) or the distance between any particle whatever is to the diameter of the particle as 1 to $10\frac{5}{12}$ or as 12 to 125. But ef , or the middle distance between the particles, is, according to our calculation, equal to a semi-diameter.

Since particles are so situated, then one moves with all the rest, and one passes through the interstice between others both up and down and laterally.

166. THE MOBILITY OF THESE PARTICLES OF THE TENTH KIND
DEPENDS ON THE MOBILE CHARACTER OF THE CIRCUM-
FLUENT MATTER OF THE SEVENTH AND FOURTH KINDS.

Between these particles of the tenth kind, matter of the seventh and fourth kinds flows intermittently. And because this kind of particles is endowed with the greatest mobility, therefore particles of the tenth kind owe their mobility to them. For they are incapable of mobility by themselves, since they are heavy, and possess a surface which is unyielding, so that they cannot be compressed, but remain constant in their dimensions. Hence, since they are heavy, and especially are incapable of being compressed and, consequently, of yielding to any pressure applied to them, like the particles of the ninth, seventh, sixth and third kinds, therefore they cannot be mobile of themselves, but they possess mobility from the circumfluent matter of the fourth and seventh kinds.

From these things the reason for the difference of motion in particles of the ninth and tenth kinds can be seen. The former possess a surface having the following characteristics :—it has elasticity ; action and reaction are equal and opposite ; it can take up vibrations, and also a kind of very rapid undulation. But the latter, because the surface is unyielding, are incapable of vibrating, non-reactive and inelastic ; as a result of this there is a great difference between their respective motions. And whatever motion they do possess, must be due to the circumfluent particles of the seventh and fourth kind. Also the

greater the motion in these particles the greater the motion in the particles of the tenth kind.

167. THE PARTICLES IN THIS POSITION EXERCISE PRESSURE
PROPORTIONATE TO THE ALTITUDE.

This proposition does not stand in need of much proof ; because spherical particles exercise pressure in proportion to the altitude. Every particle possesses, as it were, its own freedom. It is unfettered by neighbouring particles, it does not cohere with another except at a single least point of contact ; it can move of itself, nor does it cohere with any neighbouring particle ; hence also the weight of a particle in a higher position is communicated through the points of contact with particles below it. For if one particle rests upon four lower particles, then the weight of one is distributed over four lower particles, which together constitute a single weight ; and so these five particles rest on a lower one with two portions of weight, and, consequently, in proportion to each altitude. But if the form of the particles were not spherical, provided they were equal, a definite pressure would be possible in proportion to the altitude, but not an equal pressure in all directions laterally.

168. THESE PARTICLES AT EVERY ALTITUDE, EXERCISE
PRESSURE EQUALLY AND LATERALLY IN EVERY DIRECTION,
BOTH ABOVE AND BELOW ; AND, INDEED, IN PROPORTION
TO THE HEIGHT FROM THE SURFACE.

This can be fully proved when the particles are spherical ; but if they had any other form whatever, whether cylindrical or sinuous or eccentric, then the equality of this pressure could not be in any way proved ; there would be the greatest inequality in the pressure, which could be proved neither geometrically nor by any other way, nor could it be established theoretically. Hence it can be very clearly shown that the form of the elementary particles is spherical, and that their arrangement is most exact ; for one particle exerts pressure upon four lower ones ; and these again press upon four laterally ; while the pressure of the

lateral ones touches the higher ones also. Thus the pressure in such an arrangement of the particles extends to the higher parts, so that there is no pressure, however great it may be, which is not communicated with the lateral particles, and these with those above, and in every direction. The arrangement of these particles might be made evident to the eye, and the continuity of the pressure, and its transmission in all directions be seen therefrom ; but this must be dealt with in treating of particular questions.

169. THE PRESSURE EXERTED BY PARTICLES IS PROPORTIONATE TO THE BASE AND ALTITUDE WHATEVER THE BASE MAY BE, WHETHER LARGE OR SMALL ; AND WHATEVER MAY BE THE NUMBER OF THE SUPERINCUMBENT PARTICLES.

This follows from the two preceding paragraphs ; for if particles exercise pressure in proportion to the altitude, and if the resulting pressure is equal in all directions, then it follows that the altitude is the cause of the pressure ; and that pressure distributed to the lateral particles is exerted among the lower particles, and indeed proportionate to the base. But these points will be dealt with in treating of special subjects.

170. IF AN ABUNDANCE OF MATTER OF THE FOURTH AND SEVENTH KIND FLOWS BETWEEN THE PARTICLES UNDER CONSIDERATION, OR THOSE OF THE TENTH KIND, THEN THEY WILL BE AGAIN EXPANDED INTO SMALL SPHERES, OR A NEW PARTICLE, WHICH IS DESIGNATED A PARTICLE OF THE ELEVENTH KIND, OR THE VAPOUR PARTICLE. THIS ENCLOSES MATTER OF THE SEVENTH AND FOURTH KIND, AND HAS AIR EXTERNALLY.

At length we come to a particle which we can see with the naked eye. The others of which we have treated are beyond the reach of our sight. The truth of our theory can be seen from those things which we discern with the eye. These particles of the eleventh kind are spherical ; they can be seen with the eye when an evaporating surface is looked at obliquely.

One may see in this vapour, or in the particle of the eleventh kind, a surface consisting of water ; a kind of cavity can be discerned within, which consists of more attenuated matter, expanded by fire or the motion of particles of the fourth and seventh kind. But outside is air or a volume of particles of the ninth kind ; so that it may with probability be deduced therefrom that water can form a kind of surface and become spherical when under pressure interiorly from matter more attenuated than that which is without ; and that these two kinds of matter exercise a kind of equilibrium of pressure. But because the enclosed matter is lighter than that which is outside, therefore, on account of this lightness among particles of the ninth kind it is raised up to a certain altitude, and indeed to that region where the lightness of the particles of air floating outside equals the lightness of the vapour. We must understand that lightness of a volume of air particles equalling the vapour particle is equal to the lightness of the vapour. Then in this it is dissolved and indeed passes into rain, and thus a drop or small volume of water comes into existence which may be designated a particle of the twelfth kind.

171. VAPOUR, OR A PARTICLE OF THE ELEVENTH KIND, MAY UNDERGO CONTRACTION OR EXPANSION, AND ITS SURFACE BECOME EITHER DENSER OR MORE ATTENUATED.

Enclosed matter of the seventh and fourth kinds is that which may be very greatly contracted and expanded, hence, too, when the opportunity is given, this vapour particle of the eleventh kind may undergo expansion and contraction. For provided the same matter which flows around is expanded, or the circumfluent air is expanded, then also the vapour is proportionately expanded through the expansion of the enclosed matter ; whence, too, the greater the heat the more the amount of vapour.

So, also, when vapour enters the higher region of the air, where the pressure is less, because the altitude is less, it is immediately expanded by reason of the decrease of pressure, and when it comes still higher, it undergoes still greater expansion

until the surface water is no longer sufficient, and it is bound to be entirely dissipated. Vapour, then, by a certain expansion, would seem to be broken up or dissolved into rain or water drops, which may be called particles of the twelfth kind. But if the surface water of the vapour particle were not lacking, it would be carried still higher before it was broken up.

Similarly, if the vapour underwent compression, then it might be compressed almost to the same amount as the air. And perhaps by compression it might become a large particle, but equal to water, so that some small amount of vapour might float about within the whole of its cavity.

It, consequently, follows that if there were a volume of vapour, it also would exercise pressure, and be subject to pressure in proportion to the altitude equally in all directions, and in proportion to the base of the column; that it would be subject to undulation, and be, in its character, almost like the air, with the difference between greater and less. This also is the reason that it is able to maintain itself so long in air, and to move about with the air; that the air in no way disturbs it, although impregnated with abundance of vapours; that there is a certain affinity between these particles; and that the atmosphere is, as it were, married to the water, but expanded into vapours.

172. A VOLUME OF PARTICLES OF THE ELEVENTH KIND, OR VAPOUR, HAS THE MAXIMUM OF EXPANSION.

I do not think any element or volume of particles has so great a force of expansion as a volume consisting of vapours. The reason is that matter of the seventh and fourth kinds is enclosed, and the surface consists of water particles which have been increased in number there, so that there is not only a simple order or series of water particles, but a multiplication of them; the water particle, therefore, flows in the surface itself as if in its own natural place. But its altitude is a question of the density of the surface itself. Since, therefore, the surface of the vapour particle consists of so great a series of water

particles, it follows that it can undergo expansion only so far as the water surface allows it. For if the series of water particles were doubled, that is, if the altitude of the particles of water in the surface consisted of ten small spheres, then it could be greatly expanded, and yet the simple order of the particles would remain. If it were subsequently expanded, disruption would take place. Moreover, the particles of vapour, or those of the eleventh kind, may undergo still greater expansion; for if they constituted one volume, so that they were mutually in contact, then if one particle or one vapour particle were disrupted, its surface matter would lapse into the surfaces of lower particles, and so increase their surface matter, that they could be still further expanded. For if there were a volume of vapours, such that expansion could not extend to more than three parts of any diameter, and if some part of the vapour were disrupted, then the matter or the water of the disrupted particles would betake themselves to the surfaces of the rest, consequently, new matter would accrue, by whose help they would be more fully expanded, and the volume itself enlarged. Thus it would regain force from the destruction of neighbouring particles.

If there is some water in the bottom of a vessel, and a volume of vapour above, then fresh matter or water is continually supplied to the particles of vapour, so that they are capable of expanding more and more. And water is added to the neighbouring vapour, which through points of contact rises to the surfaces of the vapours above, and thus gives rise to an equality of expansion. Consequently, we think that in no other particles is there so great a force of distension as in those of vapours. For they are always capable of expansion, and fresh matter is constantly flowing into their surfaces, so that there is nothing to prevent a volume of such particles from having the power to raise the greatest possible weight; and it is plain from experiments that a solid mass of fused metal can be projected to a height of ten or twelve ells.

173. THERE IS ANOTHER KIND OF SPHERICAL PARTICLE WHICH HAS NO POWER OF EXPANSION.

This kind of spherical particle does not need to be designated by any name ; for such particles can arise not only from water, but also from many other fluids. Water takes the form of such spherical particles when much scattered in different directions, and if it is slowly agitated, for then the air attracts the surface of the water, and clothes, as it were, a certain volume with an aqueous surface. The difference then consists in this, that in such a spherical particle air is enclosed, and is also on the outside. The reason why such a particle has no power of expansion is that air is both within and without ; and, consequently, the interior matter is in equilibrium with the exterior matter ; for neither the matter nor the air that is within could undergo expansion, unless the exterior collapsed. And when the matter within is the same as that which is without there can be no such action or reaction, as in the case of those particles of which we have treated.

174. THE VOLUME OF ELEMENTARY PARTICLES ENDEAVOURS TO ACT UPON CERTAIN SMALL SPHERES WHATEVER THE PARTICLES, ALTHOUGH THEY MAY BE IRREGULAR IN FORM, PROVIDED THEY ARE SEPARATED AND RETAIN THEIR FLUENCY.

The elements which have been described, and the volumes of their particles, always desire to copy their own nature when occasion and opportunity are given ; hence it is clear, that when particles are separated by fire, as in the case of rocky, vitreous, saline, metallic, earthy, and other substances, they immediately strive to become vapour and spherical particles ; this one can see when fire acts upon fluid mercury. The mercury quickly assumes the vaporous state. The same is the case when particles of lead are acted upon by fire ; they are at once dissipated, becoming so light that they are lighter than air, and thus are propelled into the air as if endowed with wings. If water were

mixed with some fatty or soapy matter it would be turned into such a number of bubbles that the whole volume of water would become a volume of bubbles. There are many other points which must be dealt with when treating on special questions.

APPENDIX ON FIRE.

In our principles we have not yet dealt with the nature of fire and cold ; nor have we assigned a reason why fire can exist between these particles, nor shown in what motion of the particles it consists, and how it can act on adjacent particles. This demands a special work and particular treatment, and indeed a whole volume. For fire acts not only on particles of the third, fourth, sixth, and seventh kinds, but also on those of the ninth kind. Consequently, I could not discuss its nature before the character of all natural particles had been dealt with ; it would require an entire work. Hence, indulgent reader, you may expect a treatise from me on fire and cold, in which I hope to be able to place the whole subject clearly before you. But in the meantime I ask your indulgence for the present work, and beg you to give your opinion neither for or against it before you have given it careful consideration, and examined it with unprejudiced mind. I do not indeed say that the theory herein contained is entirely free from error ; and I shall be grateful for any correction duly made in a proper spirit.

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